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WO 2005/105136 A1

(54) Title: NANOGENE THERAPY FOR CELL PROLIFERATION DISORDERS

(57) Abstract: The present invention concerns particles comprising a chitin component, such as chitosan or a derivative thereof, associated with a polynucleotide encoding an interferon (IFN) molecule, 2-5' oligoadenylate synthetase (2-5 AS), or a combination thereof. Preferably, the chitin component comprises chitosan or a derivative thereof. The particles of the invention are useful for delivery and expression of the interferon-encoding and/or 2-5 AS-encoding polynucleotide within a host *in vitro* or *in vivo*. The invention further concerns pharmaceutical compositions comprising particles of the invention and a pharmaceutically acceptable carrier, and a method for producing particles of the present invention. The present invention further pertains to a method of inducing apoptosis in a cancer cell, such as a lung cancer cell, by contacting a target cancer cell *in vitro* or *in vivo*with an effective amount of particles of the invention. In one embodiment, a therapeutically effective amount of particles are administered to target cancer cells within a patient *in vivo,* for treatment of cancer, such as lung cancer. The particles and therapeutic methods of the invention provide anti-metastatic and anti-cancer therapeutics for cancer patients, particularly lung cancer patients.

DESCRIPTION

NANOGENE THERAPY FOR CELL PROLIFERATION DISORDERS

CROSS-REFERENCE TO RELATED APPLICATION

This application claims benefit of U.S. Provisional Application Serial No. 60/565,756, filed April 27, 2004, which is hereby incorporated by reference herein in its entirety, including any figures, tables, nucleic acid sequences, amino acid sequences, and drawings.

FIELD OF THE INVENTION

This invention pertains to particles including a chitin component, a polynucleotide encoding an interferon molecule, such as IFN-gamma (IFN-γ), or an interferon-inducible molecule such as 2'-5' oligoadenylate synthetase (2-5 AS) or interferon regulatory factor (IRF-1), or a combination of any of the foregoing, and the use of such particles for treatment of cell proliferation disorders, such as lung cancer.

BACKGROUND OF THE INVENTION

Lung cancer is one of the leading causes of death worldwide. Despite progress made in our understanding of the multiple risk factors associated with the development of lung cancer, and progress in developing novel approaches, this disease remains difficult to treat effectively. Lung cancer patients often present with locally advanced or disseminated disease. Their long-term survival is poor and such aggressive cancers are difficult to treat because of drug-induced toxicity. Non-viral plasmid DNA (pDNA)-mediated gene therapy, one of several new therapeutic approaches for lung cancer, provides a better alternative that is both safe and effective. Unlike viral vectors, which can induce an immune response with associated immunogenicity and systemic toxicity, a pDNA strategy combined with a chitosan-based nanoparticle (CBN) carrier system provides a unique approach to delivering genes by the mucosal route with limited toxicity and increased transgene expression, especially in target organs such as the lung (disclosed

in Mohapatra *et al.*, international publication WO 03/028759 A1 and Mohapatra *et al.*, U.S. patent publication 2003-0068333-A1, which are each incorporated herein by reference in their entirety).

Lung tumor development and metastasis are complex processes that include transformation, proliferation, resistance to apoptosis, neovascularization, and metastatic spread (Antoniou, K.M. *et al. Chest*, 2003, 123:209-216). A number of gene products have been identified that play critical roles in these processes. Inhibition of metastasis is one of the most important therapeutic strategies in the treatment of lung cancer, since approximately 70% of lung cancer patients die from the metastatic disease even after a complete resection of primary tumor. Metastasis involves the disruption of extracellular matrix (ECM) adhesion, ECM degradation, cell cycle disregulation, and escape from apoptosis. Thus, protection from metastasis would have to block one or more of these processes.

A complex array of endocrine activities controls cell proliferation and death in the respiratory, gastrointestinal and urinary mucosa, which are major sites of tumor development. Interferons (IFNs) have received wide attention for their anti-cancer effects and are currently used for many cancers. The major oncologic indications of IFNs include melanoma, renal cell carcinoma, AIDS-related carposi sarcoma, follicular lymphoma, hairy cell leukemia and chronic myelogenous leukemia (Antoniou, K.M. *et al. Chest*, 2003, 123:209-216). Exogenous recombinant IFNs have a shorter half-life *in vivo*, and systemic administration at moderate to high doses may cause substantial adverse effects (Gutterman, J.U. *PNAS*, 1994, 91:1198-1205; Antoniou, K.M. *et al. Chest*, 2003, 123:209-216).

To overcome the limitations inherent with therapy using cytokines *per se* (cytokine proteins or polypeptides), several investigators have used transient gene expression therapy involving these genes. Separately, IFN-γ and IL-12 have each proven effective both as prophylactics and adjuncts in therapy against diverse human diseases (Mohapatra, S.S. *Science*, 1995, 269(5230):1499; Murray, H.W. *Intensive Care Med*, 1996, 22(Suppl 4):S456-S461). Oromucosal IFN therapy was found to be effective for antiviral and antitumoral activity (Okubo, T. *et al. J Immunol*, 1999, 162:4013-4017). However, mucosal administration of IFN-γ pDNA has not been studied.

The last decade has seen tremendous progress in gene expression technology. Several investigators have utilized a replication-deficient episomal adenovirus as a vehicle for transient gene expression. Adenoviral vectors are very efficient at transducing target cells *in vitro* and *in vivo* and permit transgene expression in a dose-dependent manner (Behera, A.K. *et al. Hum Gene Ther.*, 2002, 13:1697-1709), but they do produce acute inflammation and an immune response to viral vector encoded antigens, which remain the major stumbling blocks to the application of adenovirus-mediated IFN-γ gene transfer for treating human diseases. Previous studies have demonstrated that the mucosal administration of pIFN-γ significantly decreased airway inflammation and airway hyper-responsiveness in a mouse model of grass allergic asthma. Adenoviral-mediated IFN-γ gene transfer effectively reversed established asthma in a BALB/c mouse model (Behera, A.K. *et al. Hum Gene Ther.*, 2002, 13:1697-1709).

It has recently been shown that intranasally delivered pDNA encoding interferon gamma (IFN-γ) can be used as an antiviral treatment against respiratory syncytial virus infection (Mohapatra *et al.*, U.S. Patent No. 6,489,306). Further, IFN-γ is known to induce interferon response factor (IRF-1) and 2'5' oligoadenylate synthetase (2-5 OAS), which also have antiviral properties (Behera, A.K. *et al., JBC*, 2002, 277(28):25601-25608; Mohapatra *et al.*, U.S. patent publication 2004-0009152-A1; Mohapatra *et al.*, international publication WO 03/092618 A2; which are each incorporated herein by reference in their entirety). Also, an IFN-γ producing plasmid encapsulated in a chitin-based nanoparticle, which has been referred to as "CIN", has been shown to possess anti-inflammatory and apoptosis-inducing properties and to attenuate lung inflammation and airway hypereactivity (Kumar *et al. Genet Vacc Ther*, 2003, 1(1):3; Mohapatra, international publication WO 2004/074314 A2; which are each incorporated herein by reference in their entirety).

The present inventors reasoned that intranasally administered nanoparticles capable of *de novo* production of the IFN-γ may provide a novel means of prophylaxis and/or treatment for cancer, such as metastatic lung cancer. Research in the laboratory has identified the pIFN-γ as a potential lung cancer treatment based on its ability to induce significant apoptosis in cultured lung cancer cell lines. Also, CBN complexed p-DNA encoding pIFN-γ was found to completely abrogate the development of lung tumors in a nude mouse model of metastatic lung cancer.

Non-viral mediated gene expression using plasmid DNAs (pDNAs) has a number of advantages, including ease of preparation and use, stability, and room temperature storage (Hellerman, G.R. and Mohapatra, S.S. *Gen Vacc & Ther*, 2003, 1:1). They do not replicate in mammalian cells and do not integrate into host genomes, yet they can persist in host cells and express the cloned gene for a period of weeks to months. One problem associated with the pDNA approach is inefficient gene transfer *in vivo*, especially in slow and non-dividing cells such as epithelial cells (Mohapatra, S.S. *Pediatr. Infect. Dis. J.*, 2003, 22(2 Suppl):S100-S103). CBNs protect pDNA from nuclease degradation and facilitate its entry into target cells. CBNs are prepared from chitosan, a biocompatible cationic polysaccharide from chitin extracted from crustacean shells, and have shown excellent potential for gene (Mao, H-Q. *et al. J. Controlled Release*, 2001, 70(3):399-421, which is incorporated herein by reference in its entirety) and controlled drug delivery. Chitosan is non-toxic, resistant to biodegradation, non-hemolytic, stimulates the immune system, is an anticoagulant, and has wound-healing and antimicrobial properties. Chitosan also increases transcellular and paracellular transport across the mucosal epithelium, thereby facilitating mucosal gene delivery. Another advantage of the use of CBNs for gene transport is their ability to target specific cells. Reduction of nonspecific interactions by shielding of net positive surface charges also improves targeting of CBNs.

BRIEF SUMMARY OF THE INVENTION

In one aspect, the present invention concerns particles comprising a chitin component, which is associated with a polynucleotide encoding an interferon (IFN) or an IFN-inducible protein, such as 2'-5' oligoadenylate synthatase (2-5 AS) or interferon regulatory factor (IRF-1). Preferably, the chitin component comprises chitosan or a derivative thereof. Optionally, the particles of the invention further comprise a lipid component and are referred to herein interchangeably as "chliposomes", "chlipids", "chitosan-lipid nanoparticles" or "CLNs". The particles of the invention are useful for delivery and expression of the interferon-encoding and/or IFN-inducible molecule-encoding polynucleotide within a host *in vitro* or *in vivo*. The invention further concerns a method for producing particles of the present invention.

In some embodiments, the particles of the invention comprise a polynucleotide encoding an interferon selected from the group consisting of alpha-interferon, beta-

interferon, gamma-interferon, omega-interferon, and lambda-interferon. In some embodiments, the particles of the invention comprise a polynucleotide encoding 2-5 AS or at least one catalytically active fragment thereof selected from the group consisting of the p40, p69, and p100 subunit. Such 2-5 AS subunits may be one or more splice variants, such as the 42kDa, 46kDa, 69kDa, and/or 71kDa variant. In some embodiments, the particles of the invention comprise a polynucleotide encoding IRF-1, or a biologically active fragment or homolog thereof.

In another aspect, the present invention concerns a pharmaceutical composition comprising particles comprising a chitin component and a polynucleotide encoding an interferon (IFN) molecule, an IFN-inducible molecule, or a combination thereof; and a pharmaceutically acceptable carrier. Optionally, the particles of the invention further comprise a lipid component. In one embodiment, the pharmaceutical composition is formulated for delivery through a mucosal route, such as the lungs.

In another aspect, the present invention concerns a method of treating a cell proliferation disorder by administering a therapeutically effective amount of particles to a patient in need thereof. Accordingly, a method of reducing cellular growth by administering a therapeutically effective amount of particles of the invention is contemplated, in order to reduce (partially or completely inhibit, prevent, or slow) uncontrolled cell growth. In one embodiment, an effective amount of particles are administered to a patient for treatment of cancer, such as lung cancer.

In another aspect, the present invention concerns a method of inducing apoptosis in a cancer cell, such as a lung cancer cell, by contacting a target cancer cell *in vitro* or *in vivo* with an effective amount of particles of the invention. In one embodiment, a therapeutically effective amount of particles are administered to target cancer cells within a patient *in vivo*, for treatment of cancer, such as lung cancer.

BRIEF DESCRIPTION OF THE DRAWINGS

The patent or application file contains at least one drawing executed in color. Copies of this patent or patent application publication with color drawing(s) will be provided by the Office upon request and payment of the necessary fee.

Figure 1 shows an analysis of apoptosis using fluorescence microscopy in cells transfected with pIFN-γ. The micrographs show that IFN-gamma treatment of HEp-2 cells induces apoptosis.

Figure 2 shows an immunoblot demonstrating the detection of p27kip expression and PARP cleavage in IFN-gamma treated HEp-2 cells with or without RSV infection.

Figure 3 shows immunocytochemistry following pIFN-gamma treatment. BALB/c nude mice were injected with A549 cells (5 x 10^6 cells/mouse) intravenously (i.v.) and one group treated with pIFN-gamma and another group with pVAX as control.

Figures 4A-4D show derivation and characterization of NG-042 nanoparticles. Figure 4A shows synthesis and characterization of nanochitosan particles produced by proprietary method. The products were separated by capillary gel electrophoresis. The plot shows the separation of 4 low molecular weight components. The nanogene particles were then subject to analysis of size and zeta potential using a NiComp381 Zetasizer. Results are shown in Figure 4B. The intensity weight distribution of NG042 particles showing their size of 155 nm, zeta potential=20.42. Atomic Force Microscopic analysis of Nanogene-042 particles showing oligomeric structure complexed with DNA (red arrows; upper line) is shown in Figure 4C. Figure 4D shows that lyophilzed and resuspended NG042 particles retain functionality at ambient temperatures of 23° to 55° C. Nanogene complexes of pGL3 (firefly luciferase, Promega) was lyophilized, reconstituted with water and treated for 24 hours at RT (23° C), 42° C, 55° C and -20° C. A549 cells were plated and transfected with the above complexes. Uptake and expression of DNA was allowed to occur for 24 hours. Luciferase activity was determined by using Promega's Dual Assay kit. Readings were normalized to relative luminiscence units (RLU) per mg protein.

Figures 5A-5C show characterization of NG044 particles. Figure 5A shows that expression of nanoparticle-encapsulated EGFP gene continues *in vivo* until day 10. NG044 particles were complexed with DNA (5:1) encoding green fluorescent protein and administered intranasally to groups of mice (n=3). Mice were sacrificed on the indicated days and broncho-alveolar lavage cells were examined by fluorescent microscopy. Figure 5B demonstrations the thermogelling property of NG044. NG044 forms a gel upon reacting with 2-glycerol phosphate, while NG042, another depolymerized chitosan, does not. To test the controlled release of gene expression, NG044 hydrogel was prepared

using pEGFP plasmid DNA and PVP/glutaraldehyde for gel formation. The hydrogel was freeze-dried and the powder was resuspended in water (NG044 hydrogel) and given intranasally to groups of mice (n=4). Another group received NG044 with pEGFP without gelling (Control). Gene expression in the mouse lung was measured by EGFP expression in BAL cells 10 and 20 days after administration. Results are shown in Figure 5C. The results at day 10 were similar (not shown) for control and hydrogel, whereas after 20 days mice given hydrogel continued EGFP show expression and no expression was detected in control mice.

BRIEF DESCRIPTION OF THE SEQUENCES

SEQ ID NO: 1 is a nucleotide coding sequence (CDS) for the human 40kDa splice variant of the 40/46kDa subunit ("p40 subunit") of 2'-5' oligoadenylate synthetase (National Center for Biotechnology Information (NCBI) Accession Number NM_016816).

SEQ ID NO: 2 is an amino acid sequence of the human 40kDa splice variant of the 40/46kDa subunit ("p40 subunit") of 2'-5' oligoadenylate synthetase (NCBI Accession Number NM_016816).

SEQ ID NO: 3 is a nucleotide coding sequence (CDS) for the human 46kDA splice variant of the 40/46kDa subunit ("p40 subunit") of 2'-5' oligoadenylate synthetase (National Center for Biotechnology Information (NCBI) Accession Number NM_016816).

SEQ ID NO: 4 is an amino acid sequence of the human 46kDA splice variant of the 40/46kDa subunit ("p40 subunit") of 2'-5' oligoadenylate synthetase (NCBI Accession Number NM_016816).

SEQ ID NO: 5 is a nucleotide coding sequence (CDS) for the human 69 kDA splice variant of the 69/71kDa subunit ("p69 subunit") of 2'-5' oligoadenylate synthetase (NCBI Accession Number NM_002535).

SEQ ID NO: 6 is an amino acid sequence of the human 69 kDa splice variant of the 69/71kDa subunit ("p69 subunit") of 2'-5' oligoadenylate synthetase (NCBI Accession Number NM_002535).

SEQ ID NO: 7 is a nucleotide coding sequence (CDS) for the human 71 kDA splice variant of the 69/71kDa subunit ("p69 subunit") of 2'-5' oligoadenylate synthetase (NCBI Accession Number NM_002535).

SEQ ID NO: 8 is an amino acid sequence of the human 71kDa splice variant of the 69/71kDa subunit ("p69 subunit") of 2'-5' oligoadenylate synthetase (NCBI Accession Number NM_002535).

SEQ ID NO: 9 is a nucleotide coding sequence (CDS) for the human 100kDa subunit ("p100 subunit") of 2'-5' oligoadenylate synthetase (NCBI Accession Number AF063613).

SEQ ID NO: 10 is an amino acid sequence of the human 100kDa subunit ("p100 subunit") of 2'-5' oligoadenylate synthetase (NCBI Accession Number AF063613).

SEQ ID NO: 11 is a nucleotide coding sequence (CDS) for the mouse homolog of the 2'-5' oligoadenylate synthetase 40kDa splice variant (p40 subunit) (NCBI Accession Number M33863).

SEQ ID NO: 12 is the amino acid sequence for the mouse homolog of the 2'-5' oligoadenylate synthetase 40kDa splice variant (p40 subunit) (NCBI Accession Number M33863).

SEQ ID NO: 13 is the human 2'-5' oligoadenylate synthetase 40/46kDa (p40 subunit) gene (NCBI Accession Number NM_016816).

SEQ ID NO: 14 is the human 2'-5' oligoadenylate synthetase 69/71kDa (p69 subunit) gene (NCBI Accession Number NM_002535).

SEQ ID NO: 15 is the human 2'-5' oligoadenylate synthetase 100kDa (p100 subunit) gene (NCBI Accession Number AF063613).

SEQ ID NO: 16 is the mouse homolog of the 2'-5' oligoadenylate synthetase 40kDa (p40 subunit) gene (NCBI Accession Number M33863).

SEQ ID NO: 17 is the nucleotide coding sequence (CDS) for human IFN-γ (NCBI Accession No: NM_000639.

SEQ ID NO: 18 is the amino acid sequence for human IFN-γ (NCBI Accession No: NM_000639.

SEQ ID NO:19 is the nucleotide coding sequence (CDS) for human interferon-beta (NCBI Accession No.: M25460).

SEQ ID NO:20 is the nucleotide coding sequence (CDS) for human interferon-beta-1 (NCBI Accession No.: M28622).

SEQ ID NO:21 is the nucleotide coding sequence (CDS) for a human interferon (NCBI Accession No.: L25664).

SEQ ID NO:22 is the nucleotide coding sequence (CDS) for human interferon-alpha (NCBI Accession No.: M54886 and M38682).

SEQ ID NO:23 is the nucleotide coding sequence (CDS) for human interferon-alpha-J1 (NCBI Accession No.: M34913).

SEQ ID NO:24 is the nucleotide coding sequence (CDS) for human interferon-omega-1 (NCBI Accession No.: X58822).

SEQ ID NO:25 is the nucleotide coding sequence (CDS) for human interleukin 28A (interferon, lambda 2; IL-28A) (NCBI Accession No.: NM_172138).

SEQ ID NO:26 is the nucleotide coding sequence (CDS) for human interleukin 28B (interferon lambda 3; IL-28B) (NCBI Accession No.: AY336714).

SEQ ID NO:27 is the nucleotide coding sequence (CDS) for human interleukin 28C (interferon lambda 4; IL-28C) (NCBI Accession No.: AY336717).

SEQ ID NO:28 is the nucleotide coding sequence (CDS) for human interleukin 29 (interferon lambda 1; IL-29) (NCBI Accession No.: NM_172140).

SEQ ID NO:29 is the nucleotide coding sequence (CDS) for a human interferon-like peptide (NCBI Accession No.: EE00870).

SEQ ID NO:30 is the nucleotide coding sequence (CDS) for a human interferon-like peptide (NCBI Accession No.: EE00871).

SEQ ID NO:31 is the nucleotide coding sequence (CDS) for a human interferon-regulatory factor 1 (IRF-1) (NCBI Accession No.: 002198).

DETAILED DESCRIPTION OF THE INVENTION

The present invention concerns particles comprising a chitin component, such as chitosan or a derivative thereof, associated with a polynucleotide encoding an interferon (IFN) molecule or an IFN-inducible molecule, or a combination thereof. Preferably, the particles further comprise a control sequence operably-linked to the polynucleotide, which is capable of causing expression of the polynucleotide within a host *in vitro* or *in vivo*.

In certain embodiments, the interferon molecule encoded by the polynucleotide is Type I or Type II interferon, including those commonly designated as alpha-interferon, beta-interferon, gamma-interferon, and omega-interferon (also designated α-interferon, β-interferon, γ-interferon, and ω-interferon), and combinations thereof, including the consensus sequence for alpha-interferon. In some embodiments, the alpha-interferon is $alpha_1$ or $alpha_2$-interferon. In some embodiments, the interferon is interferon α-2b. Other interferons include interferon α-2β, a fusion interferon α-/2α-1, interferon α-2e, human α1 or α2 interferon.

In some embodiments, the interferon is a hybrid interferon. The construction of hybrid polynucleotides encoding combinations of different interferon subtypes (such as α and ε; α and β, and α and F) is disclosed in U.S. Patent Nos. 4,414,150; 4,456,748; and 4,678,751, each of which are incorporated herein by reference in their entirety. U.S. Patent Nos. 4,695,623; 4,897,471; and 5,831,062, which are incorporated herein by reference in their entirety, disclose novel human leukocyte interferon polypeptides having amino acid sequences that include common or predominant amino acids found at each position among naturally-occurring alpha interferon subtype polypeptides and are referred to as consensus human leukocyte interferon. In one embodiment of the invention, the hybrid interferon is interferon α2α1.

In one embodiment, the interferon is an interferon-α. Recombinant interferon alphas, for instance, have been cloned and expressed in *E. coli* by several groups (*e.g.*, Weissmann *et al.*, *Science*, 1980, 209:1343-1349; Sreuli *et al.*, *Science*, 1980, 209:1343-1347; Goeddel *et al.*, *Nature*, 1981, 290:20-26; Henco *et al.*, *J. Mol. Biol.*, 1985, 185:227-260, each of which are incorporated herein by reference in their entirety). In some embodiments, the interferon is a human interferon alpha. In some embodiments, the interferon alpha is interferon alpha 2a or 2b.

The term "interferon" as used herein is intended to include all classes and subclasses of interferon, and deletion, insertion, or substitution variants, as well as "interferon-like" molecules such as interleukin 15 (IL-15), interleukin 28A (interferon lambda2; IL-28A), interleukin 28B (IL-28B), interleukin 28C (IL-28C), interleukin 29 (interferon lambda1; IL-29), and synthetic interferon-like peptides (*e.g.*, NCBI accession nos. E00871 and E00870). In one embodiment, the interferon-encoding polynucleotide, or its polypeptide product, is the interferon-alpha-encoding polynucleotide or its

polypeptide product. In some embodiments, the interferon-encoding polynucleotide of the particle, or its polypeptide, is the human nucleotide or amino acid sequence. The human interferon alphas, for example, are a family of proteins including at least 24 subspecies (Zoon, K. C., *Interferon*, 1987, 9:1, Gresser, I., ed., Academic Press, NY). The interferon alphas were originally described as agents capable of inducing an antiviral state in cells but are now known as pleiotropic lymphokines affecting many functions of the immune system (Openakker *et al.*, *Experimentia*, 1989, 45:513). In some embodiments, the interferon alpha is interferon alpha 2a or 2b (see, for example, WO 91/18927, which is incorporated by reference herein in its entirety), although any interferon alpha may be used. Nucleotide sequences encoding the exemplified interferons interferon-gamma; interferon-beta; interferon-beta-1; interferon; interferon-alpha; interferon-alpha-J1; interferon omega-1; interleukin 28A; interleukin 28B; interleukin 28C, interleukin 29; and interferon-like peptides are listed as SEQ ID NOs: 17 and 19-30. Particles of the invention may contain one or more of these polynucleotides or degenerate sequences encoding the same polypeptides, for example

The interferon-encoding polynucleotide may encode gamma-interferon (IFN-γ), among others. IFN-γ is a 14-18 kDalton 143 amino acid glycosylated protein that is a potent multifunctional cytokine. As used herein, "interferon-gamma", "IFN-gamma", "interferon-γ", and "IFN-γ refer to IFN-γ protein, biologically active fragments of IFN-γ, and biologically active homologs of "interferon-gamma" and "IFN-γ", such as mammalian homologs. These terms include IFN-γ-like molecules. An "IFN-γ-like molecule" refers to polypeptides exhibiting IFN-γ-like activity when the polynucleotide encoding the polypeptide is expressed, as can be determined *in vitro* or *in vivo*. For purposes of the subject invention, IFN-γ-like activity refers to those polypeptides having one or more of the functions of the native IFN-γ cytokine disclosed herein (such as induction of apoptosis). Fragments and homologs of IFN-γ retaining one or more of the functions of the native IFN-γ cytokine, such as those disclosed herein, is included within the meaning of the term "IFN-γ". In addition, the term includes a nucleotide sequence which through the degeneracy of the genetic code encodes a similar peptide gene product as IFN-γ and has the IFN-γ activity described herein. For example, a homolog of "interferon-gamma" and "IFN-γ" includes a nucleotide sequence which contains a "silent" codon substitution (*e.g.*, substitution of one codon encoding an amino acid for

another codon encoding the same amino acid) or an amino acid sequence which contains a "silent" amino acid substitution (*e.g.*, substitution of one acidic amino acid for another acidic amino acid).

An exemplified nucleotide sequence encodes human IFN-γ (Accession No: NM_000639, NCBI database, which is hereby incorporated by reference in its entirety):

1 tgaagatcag ctattagaag agaaagatca gttaagtcct ttggacctga tcagcttgat
61 acaagaacta ctgatttcaa cttctttggc ttaattctct cggaaacgat gaaatataca
121 agttatatct tggcttttca gctctgcatc gttttgggtt ctcttggctg ttactgccag
181 gacccatatg taaaagaagc agaaaacctt aagaaatatt ttaatgcagg tcattcagat
241 gtagcggata atggaactct tttcttaggc attttgaaga attggaaaga ggagagtgac
301 agaaaaataa tgcagagcca aattgtctcc ttttacttca aacttttaa aaactttaaa
361 gatgaccaga gcatccaaaa gagtgtggag accatcaagg aagacatgaa tgtcaagttt
421 ttcaatagca acaaaaagaa acgagatgac ttcgaaaagc tgactaatta ttcggtaact
481 gacttgaatg tccaacgcaa agcaatacat gaactcatcc aagtgatggc tgaactgtcg
541 ccagcagcta aaacagggaa gcgaaaaagg agtcagatgc tgtttcaagg tcgaagagca
601 tcccagtaat ggttgtcctg cctgcaatat ttgaatttta aatctaaatc tatttattaa
661 tatttaacat tatttatatg gggaatatat ttttagactc atcaatcaaa taagtattta
721 taatagcaac ttttgtgtaa tgaaaatgaa tatctattaa tatatgtatt atttataatt
781 cctatatcct gtgactgtct cacttaatcc tttgttttct gactaattag gcaaggctat
841 gtgattacaa ggctttatct caggggccaa ctaggcagcc aacctaagca agatcccatg
901 ggttgtgtgt ttatttcact tgatgataca atgaacactt ataagtgaag tgatactatc
961 cagttactgc cggtttgaaa atatgcctgc aatctgagcc agtgctttaa tggcatgtca
1021 gacagaactt gaatgtgtca ggtgaccctg atgaaaacat agcatctcag gagatttcat
1081 gcctggtgct tccaaatatt gttgacaact gtgactgtac ccaaatggaa agtaactcat
1141 ttgttaaaat tatcaatatc taatatatat gaataaagtg taagttcaca act (SEQ ID NO: 17)

MKYTSYILAFQLCIVLGSLGCYCQDPYVKEAENLKKYFNAGHSDVADNGTLFLG
ILKNWKEESDRKIMQSQIVSFYFKLFKNFKDDQSIQKSVETIKEDMNVKFFNSNK
KKRDDFEKLTNYSVTDLNVQRKAIHELIQVMAELSPAAKTGKRKRSQMLFQ
GRRASQ (SEQ ID NO: 18)

U.S. Patent Nos. 5,770,191 and 6,120,762, which are incorporated herein by reference in their entirety, describe several C-terminal fragments of IFN-gamma that may be encoded by the polynucleotide(s) carried by the particles of the invention. Other interferons that may be encoded by polynucleotides within the particles of the invention are described in U.S. patent publications 2005-0054052-A1; 2005-0054053-A1; 2005-0025742-A1; and 2005-0084478-A1; which are incorporated herein by reference in their entirety.

Interferon regulatory factor-1 (IRF-1) is an interferon-inducible molecule (*e.g.*, an interferon-stimulated gene product) (Pizzoferrato, F. *et al.*, *Cancer Res.*, 2004, 64(22):8381-8388; Pack, S.Y. *et al.*, *Eur. J. Biochem.*, 2004, 271(21):4222-4228). The nucleotide sequence encoding human IRF-1 is provided herein as SEQ ID NO: 31. Particles of the invention may contain this polynucleotide, degenerate sequences encoding the same polypeptide, or biologically active fragments thereof, for example.

2'5' oligoadenylate synthetase (2-5 AS) is an interferon-inducible molecule. In some embodiments, the particles of the invention comprise a polynucleotide encoding 2-5 AS or at least one catalytically active fragment thereof selected from the group consisting of the p40, p69, and p100 subunit. Such 2-5 AS subunits may be one or more splice variants, such as the 42kDa, 46kDa, 69kDa, and/or 71kDa variant. For example, the particles can comprise one or more nucleotide sequences encoding polypeptides comprising one more amino acid sequences set forth herein as SEQ ID NOs: 2, 4, 5, 6, 8, 10, 12, 13, 14, 15, or 16, or catalytically active fragments of these amino acids. In some embodiments, the particles comprise one or more nucleotide sequences selected from the group consisting of SEQ ID NOs: 1, 3, 5, 7, 9, 11, 13, 14, 15, 16, and 18, or a catalytically active fragment thereof.

As indicated above, the particle used in the compositions and methods of the invention comprise polynucleotides encoding an interferon, an interferon-inducible molecule, or both. For example, the particle can contain a polynucleotide encoding an interferon and 2-5 AS; encoding an interferon and IRF-1; encoding 2-5 AS and IRF-1; or encoding an interferon, 2-5 AS, and IRF-1. Combinations of an interferon and interferon-inducible molecules can be encoded by polynucleotides within a single particle or multiple different particles.

The nucleotide sequences encoding interferon and/or an interferon-inducible molecule used in the subject invention include "homologous" or "modified" nucleotide sequences. Modified nucleic acid sequences will be understood to mean any nucleotide sequence obtained by mutagenesis according to techniques well known to persons skilled in the art, and exhibiting modifications in relation to the normal sequences. For example, mutations in the regulatory and/or promoter sequences for the expression of a polypeptide that result in a modification of the level of expression of a polypeptide according to the invention provide for a "modified nucleotide sequence". Likewise, substitutions, deletions, or additions of nucleic acids to the polynucleotides of the invention provide for "homologous" or "modified" nucleotide sequences. In various embodiments, "homologous" or "modified" nucleic acid sequences have substantially the same biological or serological activity as the native (naturally occurring) interferon and/or interferon-inducible polypeptide. A "homologous" or "modified" nucleotide sequence will also be understood to mean a splice variant of the polynucleotides of the instant invention or any nucleotide sequence encoding a "modified polypeptide" as defined below.

A homologous nucleotide sequence, for the purposes of the present invention, encompasses a nucleotide sequence having a percentage identity with the bases of the nucleotide sequences of between at least (or at least about) 20.00% to 99.99% (inclusive). The aforementioned range of percent identity is to be taken as including, and providing written description and support for, any fractional percentage, in intervals of 0.01%, between 20.00% and 99.99%. These percentages are purely statistical and differences between two nucleic acid sequences can be distributed randomly and over the entire sequence length.

In various embodiments, homologous sequences exhibiting a percentage identity with the bases of the nucleotide sequences of the present invention can have 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, or 99 percent identity with the polynucleotide sequences of the instant invention. Homologous nucleic acid sequences and amino acid sequences include mammalian homologs of the human interferon and/or interferon-inducible molecule

nucleic acid sequences and amino acid sequences, including homologs of biologically active fragments, such as biologically active subunits.

Both protein and nucleic acid sequence homologies may be evaluated using any of the variety of sequence comparison algorithms and programs known in the art. Such algorithms and programs include, but are by no means limited to, TBLASTN, BLASTP, FASTA, TFASTA, and CLUSTALW (Pearson and Lipman *Proc. Natl. Acad. Sci. USA*, 1988, 85(8):2444-2448; Altschul *et al. J. Mol. Biol.*, 1990, 215(3):403-410; Thompson *et al. Nucleic Acids Res.*, 1994, 22(2):4673-4680; Higgins *et al. Methods Enzymol.*, 1996, 266:383-402; Altschul *et al. J. Mol. Biol.*, 1990, 215(3):403-410; Altschul *et al. Nature Genetics*, 1993, 3:266-272).

Nucleotide sequences encoding polypeptides with enhanced interferon activity or interferon-inducible molecule activity (such as 2-5 AS catalytic activity and/or IRF-1 activity) can be obtained by "gene shuffling" (also referred to as "directed evolution", and "directed mutagenesis"), and used in the compositions and methods of the present invention. Gene shuffling is a process of randomly recombining different sequences of functional genes (recombining favorable mutations in a random fashion) (U.S. Patent Nos. 5,605,793; 5,811,238; 5,830,721; and 5,837,458). Thus, protein engineering can be accomplished by gene shuffling, random complex permutation sampling, or by rational design based on three-dimensional structure and classical protein chemistry (Cramer *et al.*, *Nature*, 391:288-291, 1998; and Wulff *et al.*, *The Plant Cell*, 13:255-272, 2001)

Identity and similarity of related nucleic acid molecules and polypeptides can be readily calculated by known methods. Such methods include, but are not limited to, those described in Computational Molecular Biology, Lesk, A. M., ed., Oxford University Press, New York, 1988;York (1988); Biocomputing: Informatics and Genome Projects, Smith, D. W., ed., Academic Press, New York, 1993;York (1993); Computer Analysis of Sequence Data, Part 1, Griffin, A. M., and Griffin, H. G., eds., Humana Press, New Jersey, 1994;Jersey (1994); Sequence Analysis in Molecular Biology, von Heinje, G., Academic Press, 1987; Press (1987); Sequence Analysis Primer, Gribskov, M. and Devereux, J., eds., M. Stockton Press, New York, 1991;York (1991); and Carillo *et al.*, *SIAM J. Applied Math.*, 1988, 48:1073.

The particles, methods, and compositions of the present invention can utilize biologically active fragments of nucleic acid sequences encoding interferon and/or

interferon-inducible molecules. Representative fragments of the polynucleotide sequences according to the invention will be understood to mean any polynucleotide fragment having at least 8 or 9 consecutive nucleotides, preferably at least 12 consecutive nucleotides, and still more preferably at least 15 or at least 20 consecutive nucleotides of the sequence from which it is derived. The upper limit for such fragments is the total number of nucleotides found in the full-length sequence (or, in certain embodiments, of the full length open reading frame (ORF) identified herein).

In other embodiments, fragments can comprise consecutive nucleotides of 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, and up to one nucleotide less than the full-length interferon and/or 2-5 AS coding sequences (or, in some embodiments, up to the full length of nucleotides in the open reading frame (ORF)).

In some embodiments, fragments comprise biologically active subunits (such as the p40 subunit of 2-5 AS (*e.g.*, 40kDa, 42kDa, 46kDa, or other splice variant), p69 subunit of 2-5 AS (*e.g.*, 69 kDa, 71 kDa, or other splice variant), p100 subunit of 2-5 AS, or combinations thereof).

It is also well known in the art that restriction enzymes can be used to obtain biologically active fragments of nucleic acid sequences, such as those encoding interferon and/or interferon-inducible molecules. For example, *Bal*31 exonuclease can be conveniently used for time-controlled limited digestion of DNA (commonly referred to as "erase-a-base" procedures). See, for example, Maniatis *et al.* (1982) *Molecular Cloning: A Laboratory Manual,* Cold Spring Harbor Laboratory, New York; Wei *et al.* [1983] *J. Biol. Chem.* 258:13006-13512.

Optionally, each particle of the invention further comprises a lipid component that is complexed with the chitin and polynucleotide components of the particle. Since efficient gene expression *in vivo* requires both complex formation for cell uptake and prevention of nucleotide degradation and complex dissociation for transcription by RNA polymerase, a combination of a chitin component and lipid component (such as chitosan

and liposomes, respectively) may lead to increased gene delivery and expression *in vivo*. Therefore, this embodiment of the particle combines these two different carrier systems (also referred to herein interchangeably as "chliposomes", "chlipids", "chitosan-lipid nanoparticles" or "CLNs") to significantly increase polynucleotide transfection and expression. Preferably, the components of the chlipid are oriented such that the polynucleotide is surrounded by a lipid monolayer, with polynucleotide-lipid inverted cylindrical micelles arranged in a hexagonal lattice. Methods for producing CLNs containing polynucleotides encoding interferon-gamma are described in Mohapatra *et al.* international publication WO 2004/074314 A2, which is hereby incorporated herein in its entirety.

The present invention further includes a method for producing the particles of the invention by mixing (*e.g.*, complexing) a polynucleotide and a chitin component, such as chitosan or a chitosan derivative, to form a particle comprising a binary complex of the polynucleotide and the chitin component. Optionally, the method further comprises mixing (complexing) a lipid with the polynucleotide and chitin component to form a particle (CLN) comprising a multiplex of the polynucleotide, the chitin component, and the lipid. Typically, the particles of the present invention range in size from the nanometer range (*e.g.*, less than one micrometer; nanoparticles) to the micrometer size range (*e.g.*, about one micrometer or larger). Methods for producing chitosan-based DNA particles are described in Mohapatra, S.S. *Pediatr. Infect. Dis. J.*, 2003, 22(2 suppl.):S100-S103: Kumar, M. *et al.*, *Hum. Gene Ther.*, 2002, 13(12):1415-1425; Kumar *et al.*, *Genetic Vaccines and Therapy*, 2003, 1:3; and Mohapatra *et al.*, international publication no. WO 2004/074314 A2; each of which are incorporated herein by reference in their entirety.

The type of reaction vessel or substrate utilized for producing the particles of the present invention, or the size of the vessel or substrate, is not critical. Any vessel or substrate capable of holding or supporting the reactants so as to allow the reaction to take place can be used. It should be understood that, unless expressly indicated to the contrary, the terms "adding", "contacting", "mixing", "reacting", "combining" and grammatical variations thereof, are used interchangeably to refer to the mixture of reactants of the method of the present invention (such as plasmid DNA or a non-

polynucleotide agent such as chitosan or a chitosan derivative, lipid, and so forth), and the reciprocal mixture of those reactants, one with the other (*i.e.*, vice-versa), in any order.

It will be readily apparent to those of ordinary skill in the art that a number of general parameters can influence the efficiency of transfection or polynucleotide delivery. These include, for example, the concentration of polynucleotide to be delivered, the concentration of the chitin component (such as chitosan or a chitosan derivative), and the concentration of lipid (for chlipids of the present invention). For *in vitro* delivery, the number of cells transfected, the medium employed for delivery, the length of time the cells are incubated with the particles of the invention, and the relative amount of particles can influence delivery efficiency. For example, a 1:5 ratio of polynucleotide to lipid, 1:5 ratio of polynucleotide to chitosan, and 20% serum is suitable. These parameters can be optimized for particular cell types and conditions. Such optimization can be routinely conducted by one of ordinary skill in the art employing the guidance provided herein and knowledge generally available to those skilled in the art. It will also be apparent to those of ordinary skill in the art that alternative methods, reagents, procedures and techniques other than those specifically detailed herein can be employed or readily adapted to produce the particles and compositions of the invention. Such alternative methods, reagents, procedures and techniques are within the spirit and scope of this invention.

In accordance with the present invention, the polynucleotides carried by the particles are conjugated with a chitin component, such as chitosan or chitosan derivatives. For example, DNA chitosan nanospheres can be generated, as described by Roy, K. *et al.* (*Nat Med*, 1999, 5:387). Chitosan allows increased bioavailability of the nucleic acid sequences because of protection from degradation by serum nucleases in the matrix and thus has great potential as a mucosal gene delivery system. Chitosan also has many beneficial effects, including anticoagulant activity, wound-healing properties, and immunostimulatory activity, and is capable of modulating immunity of the mucosa and bronchus-associated lymphoid tissue.

The term "chitosan", as used herein, will be understood by those skilled in the art to include all derivatives of chitin, or poly-N-aceryl-D-glucosamine (including all polyglucosamine and oligomers of glucosamine materials of different molecular weights), in which the greater proportion of the N-acetyl groups have been removed through hydrolysis. Generally, chitosans are a family of cationic, binary hetero-polysaccharides

composed of (1→4)-linked 2-acetamido-2-deoxy-β-D-glucose (GlcNAc, A-unit) and 2-amino-2-deoxy-β-D-glucose, (GlcN; D-unit) (Varum K.M. *et al.*, *Carbohydr. Res.*, 1991, 217:19-27; Sannan T. *et al.*, *Macromol. Chem.*, 1776, 177:3589-3600). Preferably, the chitosan has a positive charge. Chitosan, chitosan derivatives or salts (*e.g.*, nitrate, phosphate, sulphate, hydrochloride, glutamate, lactate or acetate salts) of chitosan may be used and are included within the meaning of the term "chitosan". As used herein, the term "chitosan derivatives" are intended to include ester, ether or other derivatives formed by bonding of acyl and/or alkyl groups with OH groups, but not the NH_2 groups, of chitosan. Examples are O-alkyl ethers of chitosan and 0-acyl esters of chitosan. Modified chitosans, particularly those conjugated to polyethylene glycol, are included in this definition. Low and medium viscosity chitosans (for example CL113, G210 and CL110) may be obtained from various sources, including PRONOVA Biopolymer, Ltd. (UK); SEIGAGAKU America Inc. (Maryland, USA); MERON (India) Pvt, Ltd. (India); VANSON Ltd. (Virginia, USA); and AMS Biotechnology Ltd. (UK). Suitable derivatives include those which are disclosed in Roberts, Chitin Chemistry, MacMillan Press Ltd., London (1992). Optimization of structural variables such as the charge density and molecular weight of the chitosan for efficiency of polynucleotide delivery and expression is contemplated and encompassed by the present invention.

The chitosan (or chitosan derivative or salt) used preferably has a molecular weight of 4,000 Dalton or more, preferably in the range 25,000 to 2,000,000 Dalton, and most preferably about 50,000 to 300,000 Dalton. Chitosans of different low molecular weights can be prepared by enzymatic degradation of chitosan using chitosanase or by the addition of nitrous acid. Both procedures are well known to those skilled in the art and are described in various publications (Li *et al.*, *Plant Physiol. Biochem.*, 1995, 33: 599-603; Allan and Peyron, *Carbohydrate Research*, 1995, 277:257-272; Damard and Cartier, *Int. J. Biol. Macromol.*, 1989, 11: 297-302). Preferably, the chitosan is water-soluble and may be produced from chitin by deacetylation to a degree of greater than 40%, preferably between 50% and 98%, and more preferably between 70% and 90%.

The lipid component utilized for the particles, compositions, and methods of the present invention is preferably a phospholipid or cationic lipid. Cationic lipids are amphipathic molecules, containing hydrophobic moieties such as cholesterol or alkyl side chains and a cationic group, such as an amine. Phospholipids are amphipathic molecules

containing a phosphate group and fatty acid side chains. Phospholipids can have an overall negative charge, positive charge, or neutral charge, depending on various substituents present on the side chains. Typical phospholipid hydrophilic groups include phosphatidyl choline, phosphatidylglycerol, and phosphatidyl ethanolamine moieties. Typical hydrophobic groups include a variety of saturated and unsaturated fatty acid moieties. The lipids used in the present invention include cationic lipids that form a complex with the genetic material (*e.g.*, polynucleotide), which is generally polyanionic, and the chitosan or chitosan derivative. The lipid may also bind to polyanionic proteoglycans present on the surface of cells. The cationic lipids can be phospholipids or lipids without phosphate groups.

A variety of suitable cationic lipids are known in the art, such as those disclosed in International Publication No. WO 95/02698, the disclosure of which is herein incorporated by reference in its entirety. Exemplified structures of cationic lipids useful in the particles of the present invention are provided in Table 1 of International Publication No. WO 95/02698. Generally, any cationic lipid, either monovalent or polyvalent, can be used in the particles, compositions and methods of the present invention. Polyvalent cationic lipids are generally preferred. Cationic lipids include saturated and unsaturated allyl and alicyclic ethers and esters of amines, amides or derivatives thereof. Straight-chain and branched alkyl and alkene groups of cationic lipids can contain from 1 to about 25 carbon atoms. Preferred straight-chain or branched alkyl or alkene groups have six or more carbon atoms. Alicyclic groups can contain from about 6 to 30 carbon atoms. Preferred alicyclic groups include cholesterol and other steroid groups. Cationic lipids can be prepared with a variety of counterions (anions) including among others: chloride, bromide, iodide, fluoride, acetate, trifluoroacetate, sulfate, nitrite, and nitrate.

Transfection efficiency can be increased by using a lysophosphatide in particle formation. Preferred lysophosphatides include lysophosphatidylcholines such as I-oleoyllysophosphatidylcholine and lysophosphatidylethanolamines. Well known lysophosphatides which may be used include DOTMA (dioleyloxypropyl trimethylammonium chloride/DOPE (*i.e.*, LIPOFECTIN, GIBCO/BRL, Gaithersburg, Md.), DOSPA, (dioleyloxy sperminecarboxamidoethyl dimethylpropanaminium trifuoroacetate)/DOPE (*i.e.*, LIPOFECTAMINE), LIPOFECTAMINE 2000, and DOGS

(dioctadecylamidospermine) (*i.e.*, TRANSFECTAM), and are all commercially available. Additional suitable cationic lipids structurally related to DOTMA are described in U.S. Patent No. 4,897,355, which is herein incorporated by reference in its entirety.

TRANSFECTAM belongs to a group of cationic lipids called lipopolamines (also referred to as second-generation cationic lipids) that differ from the other lipids used in gene transfer mostly by their spermine head group. The polycationic spermine head group promotes the formation of lipoplexes with better-defined structures (*e.g.*, 50 to 100 nm) (Remy J.S. *et al.*, "Gene Transfer with Lipospermines and Polyethylenimines", *Adv. Drug Deliv. Rev.*, 1998, 30:85-95).

Another useful group of cationic lipids related to DOTMA and DOTAP that may be utilized are commonly called DORI-ethers or DORI-esters, such as (DL-1-O-oleyl-2-oleyl-3-dimethylaminopropyl-β-hydroxyethylammonium or DL-1-oleyl-2-O oleyl-3-dimethyl-aminopropyl-β-hydroxyethylammonium). DORI lipids differ from DOTMA and DOTAP in that one of the methyl groups of the trimethylammonium group is replaced with a hydroxyethyl group. The oleoyl groups of DORI lipids can be replaced with other alkyl or alkene groups, such as palmitoyl or stearoyl groups. The hydroxyl group of the DORI-type lipids can be used as a site for further functionalization, for example for esterification to amines, like carboxyspermine. Additional cationic lipids which can be employed in the particles, compositions, and methods of the present invention include those described in International Publication No. WO 91/15501, which is herein incorporated by reference in its entirety. Cationic sterol derivatives, like 3 β [N-(N',N'-dimethylaminoethane)carbamoyl] cholesterol (DC-Chol) in which cholesterol is linked to a trialkyammonium group, can also be employed in the present invention. DC-Chol is reported to provide more efficient transfection and lower toxicity than DOTMA-containing liposomes for some cell lines. DC-Chol polyamine variants such as those described in International Publication No. WO 97/45442 may also be used. Polycationic lipids containing carboxyspermine are also useful in the delivery vectors or complexes of this invention. EP-A-304111 describes carboxyspermine containing cationic lipids including 5-carboxyspermylglycine dioctadecyl-amide (DOGS), as referenced above, and dipalmitoylphosphatidylethanolamine 5-carboxyspermylamide (DPPES). Additional cationic lipids can be obtained by replacing the octadecyl and palmitoyl groups of DOGS and DPPES, respectively, with other alkyl or alkene groups. Cationic lipids can

optionally be combined with non-cationic co-lipids, preferably neutral lipids, to form the chlipids of the invention. One or more amphiphilic compounds can optionally be incorporated in order to modify the particle's surface property.

Suitable cationic lipids include esters of the Rosenthal Inhibitor (RI) (DL-2,3-distearoyloxypropyl(dimethyl)-β-hydroxyethylammoniumbromide), as described in U.S. Patent No. 5,264,618, the contents of which is hereby incorporated by reference in its entirety. These derivatives can be prepared, for example, by acyl and alkyl substitution of 3-dimethylaminopropane diol, followed by quaternization of the amino group. Analogous phospholipids can be similarly prepared.

The polynucleotides (and particles containing them) are administered and dosed in accordance with good medical practice, taking into account the clinical condition of the individual patient, the site and method of administration, scheduling of administration, patient age, sex, body weight, and other factors known to medical practitioners. The therapeutically or pharmaceutically "effective amount" for purposes herein is thus determined by such considerations as are known in the art. A therapeutically or pharmaceutically effective amount of polynucleotide (such as an IFN-encoding and/or IFN-inducible molecule-encoding polynucleotide) is that amount necessary to provide an effective amount of the polynucleotide, or the corresponding polypeptide(s) when expressed *in vivo*. An effective amount of an agent, such as a polynucleotide or non-polynucleotide agent, or particles comprising such polynucleotide or non-polynucleotide agents, can be an amount sufficient to prevent, treat, reduce and/or ameliorate the symptoms and/or underlying causes of any cell proliferation disorder, such as lung cancer. In some instances, an "effective amount" is sufficient to eliminate the symptoms of the pathologic condition and, perhaps, overcome the condition itself. In the context of the present invention, the terms "treat" and "therapy" and the like refer to alleviate, slow the progression, prophylaxis, attenuation, or cure of an existing condition. The term "prevent", as used herein, refers to putting off, delaying, slowing, inhibiting, or otherwise stopping, reducing, or ameliorating the onset of such conditions. The therapeutic methods of the invention include prevention and/or treatment of a cell proliferation disorder.

In accordance with the present invention, a suitable single dose size is a dose that is capable of preventing or alleviating (reducing or eliminating) a symptom in a patient

when administered one or more times over a suitable time period. One of skill in the art can readily determine appropriate single dose sizes for systemic administration based on the size of a mammal and the route of administration.

In one embodiment, the cells or subject to which the particles of the invention are administered is not suffering from an RNA virus infection, such as those disclosed in Mohapatra *et al.*, international publication WO 03/092618 A2 and U.S. patent publication 2004-0009152-A1, which are incorporated herein by reference in their entirety. In another embodiment, the cells or subject to which the particles of the invention are administered is not suffering from a respiratory RNA virus infection. In another embodiment, the cells or subject to which the particles of the invention are administered is not suffering from a respiratory syncytial virus (RSV) infection.

Following administration of particles to a subject, the subject's physiological condition can be monitored in various ways well known to the skilled practitioner familiar with the hallmarks of cancer progression, or alternatively by monitoring the effects of administration of the particles on the amount and/or biological activity of the interferon and/or interferon-inducible molecule *in vivo*. Optionally, the therapeutic methods of the invention include identifying a subject suffering from a cell proliferation disorder, such as lung cancer or other cancer. Identification of the subject may include medical diagnosis of the disorder by a licensed clinician.

Mammalian species which benefit from the disclosed particles, compositions, and methods include, and are not limited to, apes, chimpanzees, orangutans, humans, monkeys; domesticated animals (*e.g.*, pets) such as dogs, cats, guinea pigs, hamsters, Vietnamese pot-bellied pigs, rabbits, and ferrets; domesticated farm animals such as cows, buffalo, bison, horses, donkey, swine, sheep, and goats; exotic animals typically found in zoos, such as bear, lions, tigers, panthers, elephants, hippopotamus, rhinoceros, giraffes, antelopes, sloth, gazelles, zebras, wildebeests, prairie dogs, koala bears, kangaroo, opossums, raccoons, pandas, hyena, seals, sea lions, elephant seals, otters, porpoises, dolphins, and whales.

As used herein, the term "patient", "subject", and "host" are used herein interchangeably and intended to include such human and non-human mammalian species and cells of those species. For example, the term "host" includes one or more host cells, which may be prokaryotic (such as bacterial cells) or eukaryotic cells (such as human or

non-human mammalian cells), and may be in an *in vivo* or *in vitro* state. After particles of the invention are administered to cells *in vitro*, the cells may be administered to a subject. For example, the particles of the invention can be administered to a subject's cells *ex vivo*, followed by administration of the cells to the subject. In those cases wherein the polynucleotide utilized is a naturally occurring nucleic acid sequence, the polynucleotide encoding the polypeptide product can be administered to subjects of the same species or different species from which the nucleic acid sequence naturally exists, for example. When the subject is a human or the target cells are human, it is preferred that polynucleotides encoding human interferons and/or interferon-inducible molecules are utilized. However, mammalian homologs may also be used, for example.

The particles of the present invention (and compositions containing them) can be administered to a subject by any route that results in delivery and/or expression of the polynucleotide (such as plasmid DNA) or delivery of other non-polynucleotide agents carried by the particles at the desired site or sites. For example, the particles can be administered intravenously (I.V.), intramuscularly (I.M.), subcutaneously (S.C.), intradermally (I.D.), orally, intranasally, *etc.*

Examples of intranasal administration can be by means of a spray, drops, powder or gel and also described in U.S. Patent No. 6,489,306, which is incorporated herein by reference in its entirety. One embodiment of the present invention is the administration of the invention as a nasal spray. Alternate embodiments include administration through any oral or mucosal routes such as oral, sublingual, intravaginal or intraanal administration, and even eye drops. However, other means of drug administrations such as subcutaneous, intravenous, and transdermal are well within the scope of the present invention.

In various embodiments, the cell proliferation disorder may be cancer of a mucous membrane, such as adenocarcinoma or other cancer of the lung, respiratory tract, stomach, epithelium, *etc.* As used herein, a "lung cancer" includes either a primary lung tumor (for example, bronchogenic carcinoma or bronchial carcinoid) or a metastasis from a primary tumor of another organ or tissue (for example, breast, colon, ovary, prostate, kidney, thyroid, stomach, peritoneum, cervix, rectum, testis, bone, or melanoma).

In preferred embodiments, for cell proliferation disorders of the respiratory tract such as the lung, the particles of the invention are administered through inhalation in a

form such as an aerosol, a nebula, a mist, an atomized sample, liquid drops, *etc.* The particles are preferably delivered to the target respiratory tract tissue with a pharmacokinetic profile that results in the delivery of an effective dose of the polynucleotide carried by the particles. In preferred embodiments, at least 1%, more preferably at least 5%, even more preferably at least 10%, still more preferably at least 20%, and most preferably at least 30% or more of the administered particles preferably undergo apical to basolateral transcytosis from the pulmonary lumen.

In certain embodiments, the tumor in a subject is a primary tumor, such as that of the lung; however, the tumor in a subject may be a secondary tumor, such as a pulmonary metastasis from a primary tumor that is not of the lung. In various embodiments, the primary tumor is selected from the group consisting of a sarcoma, an adenocarcinoma, a choriocarcinoma, and a melanoma. In other embodiments, the tumor is a colon adenocarcinoma, a breast adenocarcinoma, an Ewing's sarcoma, or an osteosarcoma. For example, the primary tumor may be a renal cell carcinoma and the secondary tumor a tumor of the lung. In various embodiments, the clinical presentation of the pulmonary metastasis is a solitary metastasis, a cannonball, a lymphangitis carcinoimatosa, or a pleural effusion. A "primary" tumor is the original tumor in a subject. A "secondary" tumor is a cancer that has metastasized from the organ in which it first appeared to another organ.

Cell proliferation disorders include but are not limited to solid tumors, such as cancers of the breast, respiratory tract, brain, reproductive organs, digestive tract, urinary tract, eye, liver, skin, head and neck, thyroid, parathyroid and their distant metastases. Those disorders also include lymphomas, sarcomas, adenocarcenomas, and leukemias.

Cancers of any organ can be treated, such as cancers of the colon, pancreas, breast, prostate, bone, liver, kidney, lung, testes, skin, pancreas, stomach, colorectal cancer, renal cell carcinoma, hepatocellular carcinoma, melanoma, *etc.*

Examples of breast cancer include, but are not limited to, invasive ductal carcinoma, invasive lobular carcinoma, ductal carcinoma *in situ*, and lobular carcinoma *in situ*. Examples of cancers of the respiratory tract include, but are not limited to, small-cell and non-small-cell lung carcinoma, as well as bronchial adenoma and pleuropulmonary blastoma. Examples of brain cancers include, but are not limited to, brain stem and hypophtalmic glioma, cerebellar and cerebral astrocytoma,

medulloblastoma, ependymoma, as well as neuroectodermal and pineal tumor. Tumors of the male reproductive organs include, but are not limited to, prostate and testicular cancer. Tumors of the female reproductive organs include, but are not limited to, endometrial, cervical, ovarian, vaginal, and vulvar cancer, as well as sarcoma of the uterus. Tumors of the digestive tract include, but are not limited to, anal, colon, colorectal, esophageal, gallbladder, gastric, pancreatic, rectal, small-intestine, and salivary gland cancers. Tumors of the urinary tract include, but are not limited to, bladder, penile, kidney, renal pelvis, ureter, and urethral cancers. Eye cancers include, but are not limited to, intraocular melanoma and retinoblastoma. Examples of liver cancers include, but are not limited to, hepatocellular carcinoma (liver cell carcinomas with or without fibrolamellar variant), cholangiocarcinoma (intrahepatic bile duct carcinoma), and mixed hepatocellular cholangiocarcinoma. Skin cancers include, but are not limited to, squamous cell carcinoma, Kaposi's sarcoma, malignant melanoma, Merkel cell skin cancer, and non-melanoma skin cancer. Head-and-neck cancers include, but are not limited to, laryngeal, hypopharyngeal, nasopharyngeal, and/or oropharyngeal cancers, and lip and oral cavity cancer. Lymphomas include, but are not limited to, AIDS-related lymphoma, non-Hodgkin's lymphoma, cutaneous T-cell lymphoma, Hodgkin's disease, and lymphoma of the central nervous system. Sarcomas include, but are not limited to, sarcoma of the soft tissue, osteosarcoma, malignant fibrous histiocytoma, lymphosarcoma, and rhabdomyosarcoma. Leukemias include, but are not limited to, acute myeloid leukemia, acute lymphoblastic leukemia, chronic lymphocytic leukemia, chronic myelogenous leukemia, and hairy cell leukemia. In addition to reducing the proliferation of tumor cells and inducing apoptosis, the particles of the invention can also cause tumor regression, *e.g.*, a decrease in the size of a tumor, or in the extent of cancer in the body.

In addition to chemotherapeutic agents, the methods and compositions of the subject invention can incorporate treatments and agents utilizing, for example, angiogenesis inhibitors (Thalidomide, Bevacizumab), Bcl-2 antisense oligonucleotides (G3139), a PSA based vaccine, a PDGF receptor inhibitor (Gleevec), microtubule stabilizers (Epothilones), and a pro-apoptotic agent (Perifosine). Thus, the particles of the invention can be administered to a subject in combination (simultaneously or consecutively) with other agents useful for treating cell proliferation disorders (including polynucleotides encoding such agents) or other disorders. Likewise, the pharmaceutical

compositions of the subject invention can include such agents (including polynucleotides encoding such agents).

The term "polynucleotide", as used herein, refers to a polymeric form of nucleotides of any length, either ribonucleotides or deoxyribonucleotides. This term refers only to the primary structure of the molecule. Thus, the term includes double-stranded and single-stranded DNA, as well as double-stranded and single-stranded RNA. Thus, the term includes DNA, RNA, or DNA-DNA, DNA-RNA, or RNA-RNA hybrids, or protein nucleic acids (PNAs) formed by conjugating bases to an amino acid backbone. It also includes modifications, such as by methylation and/or by capping, and unmodified forms of the polynucleotide. The nucleotides may be synthetic, or naturally derived, and may contain genes, portions of genes, or other useful polynucleotides. In one embodiment, the polynucleotide comprises DNA containing all or part of the coding sequence for a polypeptide, or a complementary sequence thereof, such as interferon and/or IFN-inducible molecule. An encoded polypeptide may be intracellular, *i.e.*, retained in the cytoplasm, nucleus, or in an organelle, or may be secreted by the cell. For secretion, the natural signal sequence present in a polypeptide may be retained. When the polypeptide or peptide is a fragment of a protein, a signal sequence may be provided so that, upon secretion and processing at the processing site, the desired protein will have the natural sequence. Specific examples of coding sequences of interest for use in accordance with the present invention include the polypeptide-coding sequences disclosed herein. The polynucleotides may also contain, optionally, one or more expressible marker genes for expression as an indication of successful transfection and expression of the nucleic acid sequences contained therein.

According to the present invention, an isolated nucleic acid molecule or nucleic acid sequence is a nucleic acid molecule or sequence that has been removed from its natural milieu. As such, "isolated" does not necessarily reflect the extent to which the nucleic acid molecule has been purified.

The terms "polypeptide" and "protein" are used interchangeably herein and indicate a molecular chain of amino acids of any length linked through peptide bonds. Thus, peptides, oligopeptides, and proteins are included within the definition of polypeptide. The terms include post-translational modifications of the polypeptide, for example, glycosylations, acetylations, phosphorylations and the like. In addition, protein

fragments, analogs, mutated or variant proteins, fusion proteins and the like are included within the meaning of polypeptide.

The particles of the present invention are useful as vectors for the delivery of polynucleotides encoding interferon (such as IFN-gamma) and/or an interferon-inducible molecule (such as 2-5 AS or IRF-1) to hosts *in vitro* or *in vivo*. The term "vector" is used to refer to any molecule (*e.g.*, nucleic acid or plasmid) usable to transfer a polynucleotide, such as coding sequence information (*e.g.*, nucleic acid sequence encoding a protein or other polypeptide), to a host cell. A vector typically includes a replicon in which another polynucleotide segment is attached, such as to bring about the replication and/or expression of the attached segment. The term includes expression vectors, cloning vectors, and the like. Thus, the term includes gene expression vectors capable of delivery/transfer of exogenous nucleic acid sequences into a host cell. The term "expression vector" refers to a vector that is suitable for use in a host cell (*e.g.*, a subject's cell, tissue culture cell, cells of a cell line, *etc.*) and contains nucleic acid sequences which direct and/or control the expression of exogenous nucleic acid sequences. Expression includes, but is not limited to, processes such as transcription, translation, and RNA splicing, if introns are present. Nucleic acid sequences can be modified according to methods known in the art to provide optimal codon usage for expression in a particular expression system. The vector of the present invention may include elements to control targeting, expression and transcription of the nucleic acid sequence in a cell selective manner as is known in the art. The vector can include a control sequence, such as a promoter for controlling transcription of the exogenous material and can be either a constitutive or inducible promoter to allow selective transcription. The expression vector can also include a selection gene.

Each particle of the invention comprises a polynucleotide that is a coding sequence for an interferon, IFN-inducible molecule, or both. A "coding sequence" is a polynucleotide sequence that is transcribed into mRNA and/or translated into a polypeptide. The boundaries of the coding sequence are determined by a translation start codon at the 5'-terminus and a translation stop codon at the 3'-terminus. A coding sequence can include, but is not limited to, mRNA, cDNA, and recombinant polynucleotide sequences. Variants or analogs may be prepared by the deletion of a portion of the coding sequence, by insertion of a sequence, and/or by substitution of one

or more nucleotides within the sequence. For example, the particles of the present invention may be used to deliver coding sequences for interferon gamma, or variants or analogs thereof. Techniques for modifying nucleotide sequences, such as site-directed mutagenesis, are well known to those skilled in the art (See, *e.g.*, Sambrook *et al.*, Molecular Cloning: A Laboratory Manual, Second Edition, 1989; DNA Cloning, Vols. I and II, D.N. Glover ed., 1985). Optionally, the polynucleotides used in the particles of the present invention, and composition and methods of the invention that utilize such particles, can include non-coding sequences.

The term "operably-linked" is used herein to refer to an arrangement of flanking control sequences wherein the flanking sequences so described are configured or assembled so as to perform their usual function. Thus, a flanking control sequence operably-linked to a coding sequence may be capable of effecting the replication, transcription and/or translation of the coding sequence under conditions compatible with the control sequences. For example, a coding sequence is operably-linked to a promoter when the promoter is capable of directing transcription of that coding sequence. A flanking sequence need not be contiguous with the coding sequence, so long as it functions correctly. Thus, for example, intervening untranslated yet transcribed sequences can be present between a promoter sequence and the coding sequence, and the promoter sequence can still be considered "operably-linked" to the coding sequence. Each nucleotide sequence coding for a polypeptide will typically have its own operably-linked promoter sequence. The promoter can be a constitutive promoter, or an inducible promoter to allow selective transcription. Optionally, the promoter can be a cell-specific or tissue-specific promoter. Promoters can be chosen based on the cell-type or tissue-type that is targeted for delivery or treatment, for example.

Suitable promoters include any that are known in the art or yet to be identified that will cause expression of interferon-encoding nucleic acid sequences or IFN-inducible molecule-encoding nucleic acid sequences in mammalian cells. Suitable promoters and other regulatory sequences can be selected as is desirable for a particular application. The promoters can be inducible, tissue-specific, or event-specific, as necessary. For example, the cytomegalovirus (CMV) promoter (Boshart *et al.*, *Cell*, 1985, 41:521-530) and SV40 promoter (Subramani *et al.*, *Mol. Cell. Biol.*, 1981, 1:854-864) have been found to be suitable, but others can be used as well. Optionally, the polynucleotide used in the

particles of the subject invention includes a sequence encoding a signal peptide upstream of the interferon-encoding and/or IFN-inducible molecule-encoding sequence, thereby permitting secretion of the interferon and/or IFN-inducible molecule from a host cell. Also, various promoters may be used to limit the expression of the polypeptide in specific cells or tissues, such as lung cells.

A tissue-specific and/or event-specific promoter or transcription element that responds to the target microenviroment and physiology can also be utilized for increased transgene expression at the desired site. There has been an immense amount of research activity directed at strategies for enhancing the transcriptional activity of weak tissue-specific promoters or otherwise increasing transgene expression with vectors. It is possible for such strategies to provide enhancement of gene expression equal to one or two orders of magnitude, for example (see Nettelbeck *et al., Gene Ther.*, 1998, 5(12):1656-1664 and Qin *et al., Hum. Gene Ther.*, 1997, 8(17):2019-2019). Examples of cardiac-specific promoters are the ventricular form of MLC-2v promoter (see, Zhu *et al., Mol. Cell Biol.*, 1993, 13:4432-4444, Navankasattusas *et al., Mol. Cell Biol.*, 1992, 12:1469-1479, 1992) and myosin light chain-2 promoter (Franz *et al., Circ. Res.*, 1993, 73:629-638). The E-cadherin promoter directs expression specific to epithelial cells (Behrens *et al., PNAS*, 1991, 88:11495-11499), while the estrogen receptor (ER) 3 gene promoter directs expression specifically to the breast epithelium (Hopp *et al., J. Mammary Gland Biol.* Neoplasia, 1998, 3:73-83). The human C-reactive protein (CRP) gene promoter (Ruther *et al., Oncogene* 8:87-93, 1993) is a liver-specific promoter. An example of a muscle-specific gene promoter is human enolase (ENO3) (Peshavaria *et al., Biochem. J.*, 1993, 292(Pt 3):701-704). A number of brain-specific promoters are available such as the thy-1 antigen and gamma-enolase promoters (Vibert *et al., Eur. J. Biochem.* 181:33-39, 1989). The prostate-specific antigen promoter provides prostate tissue specificity (Pang *et al., Gene Ther.*, 1995, 6(11):1417-1426; Lee *et al., Anticancer Res.*, 1996, 16(4A):1805-1811). The surfactant protein B promoter provides lung specificity (Strayer *et al., Am. J. Respir. Cell Mol. Biol.*, 1998, 18(1):1-11). Any of the aforementioned promoters may be selected for targeted or regulated expression of the interferon-encoding and/or IFN-inducible protein-encoding polynucleotide.

The particles of the present invention can be targeted through various means. As indicated above, tissue-specific promoters or event-specific promoters may be utilized

with polynucleotides encoding interferon and/or IFN-inducible molecules to further optimize and localize expression at target sites, such as within diseased tissues (*e.g.*, cancer cells or tissues containing cancer cells). Robson *et al.* review various methodologies and vectors available for delivering and expressing a polynucleotide *in vivo* for the purpose of treating cancer (Robson, T. Hirst, D.G., *J. Biomed. and Biotechnol.*, 2003, 2003(2):110-137, which is hereby incorporated by reference herein in its entirety). Among the various targeting techniques available, transcriptional targeting using tissue-specific and event-specific transcriptional control elements is discussed. For example, Table 1 at page 112 of the Robson *et al.* publication lists several tissue-specific promoters useful in cancer therapy. Tables 2-4 of the Robson *et al.* publication list tumor-specific promoters, tumor environment-specific promoters, and exogenously controlled inducible promoters, many of which were available at the time the patent application was filed. The successful delivery and expression of the p53 tumor suppressor gene *in vivo* has been documented (Horowitz, J. *Curr. Opin. Mol. Ther.*, 1999, 1(4):500-509; Von Gruenigen, V.E. *et al. Int. J. Gynecol. Cancer*, 1999, 9(5):365-372; Fujiwara, T. *et al.*, *Mol. Urol.*, 2000, 4(2):51-54, respectively).

Many techniques for delivery of drugs and proteins are available in the art to reduce the effects of enzymatic degradation, to facilitate cell uptake, and to reduce any potential toxicity to normal (undiseased) cells, *etc.* Such methods and reagents can be utilized for administration of particles of the invention and their polynucleotide cargo to cells *in vitro* or *in vivo*. For example, peptides known as "cell penetrating peptides" (CPP) or "protein transduction domains" (PTD) have an ability to cross the cell membrane and enter the cell. PTDs can be linked to a cargo moiety such as a drug, peptide, or full-length protein, and can transport the moiety across the cell membrane. One well characterized PTD is the human immunodeficient virus (HIV)-1 Tat peptide (see, for example, Frankel *et al.*, U.S. Patent Nos. 5,804,604; 5,747,641; 6,674,980; 5,670,617; and 5,652,122; Fawell, S. *et al.*, *Proc. Natl. Acad. Sci.* U.S.A., 1994, 91:664-668). Peptides such as the homeodomain of *Drosophila* antennapedia (ANTp) and arginine-rich peptides display similar properties (Derossi, D. *et al.*, *J. Biol. Chem.*, 1994, 269:10444-10450; Derossi, D. *et al.*, *Trends Cell Biol.*, 1998, 8:84-87; Rojas, M. *et al.*, *Nat. Biotechnol.*, 1998, 16:370-375; Futaki, S. *et al.*, *J. Biol. Chem.*, 2001, 276:5836-5840). VP22, a tegument protein from Herpes simplex virus type 1 (HSV-1), also has the

ability to transport proteins across a cell membrane (Elliot *et al.*, *Cell*, 1997, 88:223-233; Schwarze S.R. *et al.*, *Trends Pharmacol. Sci.*, 2000, 21:45-48). A common feature of these carriers is that they are highly basic and hydrophilic (Schwarze S.R. *et al.*, *Trends Cell Biol.*, 2000, 10:290-295). Coupling of these carriers to marker proteins such as beta-galactosidase has been shown to confer efficient internalization of the marker protein into cells. More recently, chimeric, in-frame fusion proteins containing these carriers have been used to deliver proteins to a wide spectrum of cell types both *in vitro* and *in vivo*. For example, VP22-p53 chimeric protein retained its ability to spread between cells and its pro-apoptotic activity, and had a widespread cytotoxic effect in p53 negative human osteosarcoma cells *in vitro* (Phelan, A. *et al.*, *Nature Biotechnol.*, 1998, 16:440-443). Intraperitoneal injection of the beta-galactosidase protein fused to the HIV-1 Tat peptide resulted in delivery of the biologically active fusion protein to all tissues in mice, including the brain (Schwarze S.R. *et al.*, *Science*, 1999, 285:1569-1572).

Liposomes of various compositions can also be used for site-specific delivery of proteins and drugs (Witschi, C. *et al.*, *Pharm. Res.*, 1999, 16:382-390; Yeh, M.K. *et al.*, *Pharm. Res.*, 1996, 1693-1698). The interaction between the liposomes and their cargo usually relies on hydrophobic interactions or charge attractions, particularly in the case of cationic lipid delivery systems (Zelphati, O. *et al.*, *J. Biol. Chem.*, 2001, 276:35103-35110). Tat peptide-bearing liposomes have also been constructed and used to deliver cargo directly into the cytoplasm, bypassing the endocytotic pathway (Torchilin V.P. *et al.*, *Biochim. Biophys. Acta-Biomembranes*, 2001, 1511:397-411; Torchilin V.P. *et al.*, *Proc. Natl. Acad. Sci.* USA, 2001, 98:8786-8791). When encapsulated in sugar-grafted liposomes, pentamidine isethionate and a derivative have been found to be more potent in comparison to normal liposome-encapsulated drug or to the free drug (Banerjee, G. *et al.*, *J. Antimicrob. Chemother.*, 1996, 38(1):145-150). A thermo-sensitive liposomal taxol formulation (heat-mediated targeted drug delivery) has been administered *in vivo* to tumor-bearing mice in combination with local hyperthermia, and a significant reduction in tumor volume and an increase in survival time was observed compared to the equivalent dose of free taxol with or without hyperthermia (Sharma, D. *et al.*, *Melanoma Res.*, 1998, 8(3):240-244). Topical application of liposome preparations for delivery of insulin, IFN-alpha, IFN-gamma, and prostaglandin E1 have met with some success (Cevc G. *et al.*, *Biochim. Biophys, Acta*, 1998, 1368:201-215; Foldvari M. *et al.*, *J. Liposome*

Res., 1997, 7:115-126; Short S.M. *et al.*, *Pharm. Res.*, 1996, 13:1020-1027; Foldvari M. *et al.*, *Urology*, 1998, 52(5):838-843; U.S. Patent No. 5,853,755).

Antibodies represent another targeting device that may make particle uptake tissue-specific or cell-specific (Mastrobattista, E. *et al.*, *Biochim. Biophys. Acta*, 1999, 1419(2):353-363; Mastrobattista, E. *et al.*, *Adv. Drug Deliv. Rev.*, 1999, 40(1-2):103-127). The liposome approach offers several advantages, including the ability to slowly release encapsulated drugs and proteins, the capability of evading the immune system and proteolytic enzymes, and the ability to target tumors and cause preferentially accumulation in tumor tissues and their metastases by extravasation through their leaky neovasculature. Other carriers have also been used to deliver anti-cancer drugs to neoplastic cells, such as polyvinylpyrrolidone nanoparticles and maleylated bovine serum albumin (Sharma, D. *et al.*, *Oncol. Res.*, 1996, 8(7-8):281-286; Mukhopadhyay, A. *et al.*, *FEBS Lett.*, 1995, 376(1-2):95-98). Thus, using targeting and encapsulation technologies, which are very versatile and amenable to rational design and modification, delivery of particles of the invention to desired cells can be further facilitated.

As indicated above, the particles of the present invention can include a lipid component, such as a liposome. According to the present invention, a liposome comprises a lipid composition that is capable of fusing with the plasma membrane of a cell, thereby allowing the liposome to deliver a nucleic acid molecule and/or a protein composition into a cell. Some preferred liposomes include those liposomes commonly used in gene delivery methods known to those of skill in the art. Some preferred liposome delivery vehicles comprise multilamellar vesicle (MLV) lipids and extruded lipids, although the invention is not limited to such liposomes. Methods for preparation of MLVs are well known in the art. "Extruded lipids" are also contemplated. Extruded lipids are lipids that are prepared similarly to MLV lipids, but which are subsequently extruded through filters of decreasing size, as described in Templeton *et al.*, *Nature Biotech.*, 1997, 15:647-652, which is incorporated herein by reference in its entirety. Small unilamellar vesicle (SUV) lipids can also be used for preparing particles of the present invention. Other preferred liposome delivery vehicles comprise liposomes having a polycationic lipid composition (*i.e.*, cationic liposomes). For example, cationic liposome compositions include, but are not limited to, any cationic liposome complexed with cholesterol, and without limitation, include DOTMA and cholesterol, DOTAP and

cholesterol, DOTIM and cholesterol, and DDAB and cholesterol. Liposomes utilized in the present invention can be any size, including from about 10 to 1000 nanometers (nm), or any size in between.

A liposome delivery vehicle can be modified to target a particular site in a mammal, thereby targeting and making use of an interferon-encoding and/or IFN-inducible molecule-encoding nucleic acid molecule of the present invention at that site. Suitable modifications include manipulating the chemical formula of the lipid portion of the delivery vehicle. Manipulating the chemical formula of the lipid portion of the delivery vehicle can elicit the extracellular or intracellular targeting of the delivery vehicle. For example, a chemical can be added to the lipid formula of a liposome that alters the charge of the lipid bilayer of the liposome so that the liposome fuses with particular cells having particular charge characteristics. In some embodiments, a liposome can be directed to a particular target cell or tissue by using a targeting agent, such as an antibody, soluble receptor or ligand, incorporated with the liposome, to target a particular cell or tissue to which the targeting molecule can bind. Targeting liposomes are described, for example, in Ho *et al.*, *Biochemistry*, 1986, 25: 5500-6; Ho *et al.*, *J Biol Chem*, 1987a, 262: 13979-84; Ho *et al.*, *J Biol Chem*, 1987b, 262: 13973-8; and U.S. Patent No. 4,957,735 to Huang *et al.*, each of which is incorporated herein by reference in its entirety). In one embodiment, if avoidance of the efficient uptake of injected liposomes by reticuloendothelial system cells due to opsonization of liposomes by plasma proteins or other factors is desired, hydrophilic lipids, such as gangliosides (Allen *et al.*, *FEBS Lett*, 1987, 223: 42-6) or polyethylene glycol (PEG)-derived lipids (Klibanov *et al.*, *FEBS Lett*, 1990, 268: 235-7), can be incorporated into the bilayer of a conventional liposome to form the so-called sterically-stabilized or "stealth" liposomes (Woodle *et al.*, *Biochim Biophys Acta*, 1992, 1113: 171-99). Variations of such liposomes are described, for example, in U.S. Patent No. 5,705,187 to Unger *et al.*, U.S. Patent No. 5,820,873 to Choi *et al.*, U.S. Patent No. 5,817,856 to Tirosh *et al.*; U.S. Patent No. 5,686,101 to Tagawa *et al.*; U.S. Patent No. 5,043,164 to Huang *et al.*, and U.S. Patent No. 5,013,556 to Woodle *et al.*, all of which are incorporated herein by reference in their entireties).

The size of the particle provides another means for targeting the particles of the invention to cells or tissues. For example, relatively small particles of the invention can be made to efficiently target ischemic tissue and tumor tissue, as described in U.S. Patent

No. 5,527,538, and U.S. Patent Nos. 5,019,369, 5,435,989 and 5,441,745, the contents of which are hereby incorporated by reference in their entirety.

The particles of the invention can be targeted according to the mode of administration. For example, lung or other respiratory epithelial tissue can be targeted by intranasal administration, cervical cells can be targeted by intravaginal administration, and prostate tumors can be targeted by intrarectal administration. Skin cancer can be targeted by topical administration. Depending on location, tumors can be targeted locally, such as by injection, into the tumor mass.

Particles of the invention can be targeted by incorporating a ligand such as an antibody, a receptor, or other compound known to target particles such as liposomes or other vesicles to various sites. The ligands can be attached to cationic lipids used to form the particles of the present invention, or to a neutral lipid such as cholesterol used to stabilize the particle. Ligands that are specific for one or more specific cellular receptor sites are attached to a particle to form a delivery vehicle that can be targeted with a high degree of specificity to a target cell population of interest.

Suitable ligands for use in the present invention include, but are not limited to, sugars, proteins such as antibodies, hormones, lectins, major histocompatibility complex (MHC), and oligonucleotides that bind to or interact with a specific site. An important criteria for selecting an appropriate ligand is that the ligand is specific and is suitably bound to the surface of the particles in a manner which preserves the specificity. For example, the ligand can be covalently linked to the lipids used to prepare the particles. Alternatively, the ligand can be covalently bound to cholesterol or another neutral lipid, where the ligand-modified cholesterol is used to stabilize the lipid monolayer or bilayer.

The terms "transfection" and "transformation" are used interchangeably herein to refer to the insertion of an exogenous polynucleotide into a host, irrespective of the method used for the insertion, the molecular form of the polynucleotide that is inserted, or the nature of the host (*e.g.*, prokaryotic or eukaryotic). The insertion of a polynucleotide per se and the insertion of a plasmid or vector comprising the exogenous polynucleotide are included. The exogenous polynucleotide may be directly transcribed and translated by the host or host cell, maintained as a nonintegrated vector, for example, a plasmid, or alternatively, may be stably integrated into the host genome. The terms "administration"

and "treatment" are used herein interchangeably to refer to transfection of hosts *in vitro* or *in vivo*, using particles of the present invention.

The term "wild-type" (WT), as used herein, refers to the typical, most common or conventional form as it occurs in nature.

Thus, the present invention includes methods of gene therapy whereby polynucleotides encoding the desired gene product (an interferon, such as interferon-gamma, an IFN-inducible molecule, or both) are delivered to a subject, and the polynucleotide is expressed *in vivo*. The term "gene therapy", as used herein, includes the transfer of genetic material (*e.g.*, polynucleotides) of interest into a host to treat or prevent a genetic or acquired disease or condition phenotype, or to otherwise express the genetic material such that the encoded product is produced within the host. The genetic material of interest can encode a product (*e.g.*, a protein, polypeptide, peptide, or functional RNA) whose production *in vivo* is desired. For example, in addition to interferon and/or an IFN-inducible molecule, the genetic material can encode a hormone, receptor, enzyme, polypeptide or peptide, of therapeutic and/or diagnostic value. For a review see, in general, the text "Gene Therapy" (*Advances in Pharmacology 40*, Academic Press, 1997). The genetic material may encode a product normally found within the species of the intended host, or within a different species. For example, if the polynucleotide encodes interferon-gamma, the cytokine may be human interferon-gamma, or that of another mammal, for example, regardless of the intended host. Preferably, the polynucleotide encodes a product that is normally found in the species of the intended host. Alternatively, the genetic material may encode a novel product.

Two basic approaches to gene therapy have evolved: (1) *ex vivo* and (2) *in vivo* gene therapy. The methods of the subject invention encompass either or both. In *ex vivo* gene therapy, host cells are removed from a patient and, while being cultured, are treated *in vitro*. Generally, a functional replacement gene is introduced into the cell via an appropriate gene delivery vehicle/method (transfection, transduction, homologous recombination, *etc.*) and an expression system as needed and then the modified cells are expanded in culture and returned to the host/patient.

In *in vivo* gene therapy, target host cells are not removed from the subject, rather the gene to be transferred is introduced into the cells of the recipient organism *in situ*, that

is within the recipient. Alternatively, if the host gene is defective, the gene is repaired *in situ*.

The particle of the present invention is capable of delivery/transfer of heterologous nucleic acid sequences into a prokaryotic or eukaryotic host cell *in vitro* or *in vivo*. The particle may include elements to control targeting, expression and transcription of the nucleic acid sequence in a cell selective manner as is known in the art. It should be noted that often the 5'UTR and/or 3'UTR of the gene may be replaced by the 5'UTR and/or 3'UTR of other expression vehicles.

Optionally, the particles of the invention may have biologically active agents other than polynucleotides as a component of the complex (either instead of, or in addition to, polynucleotides). Such biologically active agents include, but are not limited to, substances such as proteins, polypeptides, antibodies, antibody fragments, lipids, carbohydrates, and chemical compounds such as pharmaceuticals. The substances can be therapeutic agents, diagnostic materials, and/or research reagents.

The present invention includes pharmaceutical compositions comprising an effective amount of particles of the invention and a pharmaceutically acceptable carrier. The pharmaceutical compositions of the subject invention can be formulated according to known methods for preparing pharmaceutically useful compositions. As used herein, the phrase "pharmaceutically acceptable carrier" means any of the standard pharmaceutically acceptable carriers. The pharmaceutically acceptable carrier can include diluents, adjuvants, and vehicles, as well as implant carriers, and inert, non-toxic solid or liquid fillers, diluents, or encapsulating material that does not react with the active ingredients of the invention. Examples include, but are not limited to, phosphate buffered saline, physiological saline, water, and emulsions, such as oil/water emulsions. The carrier can be a solvent or dispersing medium containing, for example, ethanol, polyol (for example, glycerol, propylene glycol, liquid polyethylene glycol, and the like), suitable mixtures thereof, and vegetable oils.

The pharmaceutically acceptable carrier can be one adapted for a particular route of administration. For example, if the particles of the present invention are intended to be administered to the respiratory epithelium, a carrier appropriate for oral or intranasal administration can be used.

Formulations containing carriers are described in a number of sources which are well known and readily available to those skilled in the art. For example, *Remington's Pharmaceutical Sciences* (Martin E.W., 1995, Easton Pennsylvania, Mack Publishing Company, 19th ed.) describes formulations which can be used in connection with the subject invention. Formulations suitable for parenteral administration include, for example, aqueous sterile injection solutions, which may contain antioxidants, buffers, bacteriostats, and solutes which render the formulation isotonic with the blood of the intended recipient; and aqueous and nonaqueous sterile suspensions which may include suspending agents and thickening agents. The formulations may be presented in unit-dose or multi-dose containers, for example sealed ampoules and vials, and may be stored in a freeze dried (lyophilized) condition requiring only the condition of the sterile liquid carrier, for example, water for injections, prior to use. Extemporaneous injection solutions and suspensions may be prepared from sterile powder, granules, tablets, *etc.* It should be understood that in addition to the ingredients particularly mentioned above, the formulations of the subject invention can include other agents conventional in the art having regard to the type of formulation in question.

As used herein, the terms "cancer" and "cancerous" refer to or describe the physiological condition in mammals that is typically characterized by unregulated cell growth. Examples of cancer include but are not limited to, carcinoma, lymphoma, blastoma, sarcoma, and leukemia. More particular examples of such cancers include breast cancer, prostate cancer, colon cancer, squamous cell cancer, small-cell lung cancer, non-small cell lung cancer, gastrointestinal cancer, pancreatic cancer, cervical cancer, ovarian cancer, liver cancer, *e.g.*, hepatic carcinoma, bladder cancer, colorectal cancer, endometrial carcinoma, kidney cancer, and thyroid cancer.

Other non-limiting examples of cancers are basal cell carcinoma, biliary tract cancer; bone cancer; brain and CNS cancer; choriocarcinoma; connective tissue cancer; esophageal cancer; eye cancer; cancer of the head and neck; gastric cancer; intra-epithelial neoplasm; larynx cancer; lymphoma including Hodgkin's and Non-Hodgkin's lymphoma; melanoma; myeloma; neuroblastoma; oral cavity cancer (*e.g.*, lip, tongue, mouth, and pharynx); peritoneal cancer; retinoblastoma; rhabdomyosarcoma; rectal cancer; cancer of the respiratory system; sarcoma; skin cancer; stomach cancer; testicular

cancer; uterine cancer; cancer of the urinary system, as well as other carcinomas and sarcomas.

As used herein, the term "tumor" refers to all neoplastic cell growth and proliferation, whether malignant or benign, and all pre-cancerous and cancerous cells and tissues. For example, a particular cancer may be characterized by a solid mass tumor. The solid tumor mass, if present, may be a primary tumor mass. A primary tumor mass refers to a growth of cancer cells in a tissue resulting from the transformation of a normal cell of that tissue. In most cases, the primary tumor mass is identified by the presence of a cyst, which can be found through visual or palpation methods, or by irregularity in shape, texture or weight of the tissue. However, some primary tumors are not palpable and can be detected only through medical imaging techniques such as X-rays (*e.g.*, mammography), or by needle aspirations. The use of these latter techniques is more common in early detection. Molecular and phenotypic analysis of cancer cells within a tissue will usually confirm if the cancer is endogenous to the tissue or if the lesion is due to metastasis from another site.

As used herein, the term "metastasis" refers to the process by which cancer cells are spread to distant parts of the body, such as from one organ and/or tissue to another not directly connected with it. The term is also used herein to refer to a tumor that develops through the metastatic process. Thus, as used herein, the term "metastasis" refers to neoplastic cell growth (*e.g.*, tumor cell growth) in an unregulated fashion and spread to distal tissues and organs of the body. As used herein, the phrase "inhibiting metastasis" refers to the particles slowing and/or preventing metastasis or the spread of neoplastic cells to a site remote from the primary growth area.

The term "anti-cancer activity", in reference to the particles of the invention, is intended to mean an activity which is able to substantially inhibit, slow, interfere, suppress, prevent, delay and/or arrest a cancer and/or a metastasis thereof (such as initiation, growth, spread, and/or progression thereof of such cancer and/or metastasis).

As used herein, the term "growth inhibitory amount" refers to an amount which inhibits growth of a target cell, such as a tumor cell, either *in vitro* or *in vivo*, irrespective of the mechanism by which cell growth is inhibited. In a preferred embodiment, the growth inhibitory amount inhibits growth of the target cell in cell culture by greater than

about 20%, preferably greater than about 50%, most preferably greater than about 75% (*e.g.*, from about 75% to about 100%).

The therapeutic methods of the invention can be advantageously combined with at least one additional therapeutic technique, including but not limited to chemotherapy, radiation therapy, surgery (*e.g.*, surgical excision of cancerous or pre-cancerous cells), or any other therapy known to those of skill in the art of the treatment and management of cancer, such as administration of an anti-cancer agent.

As used herein, the term "anti-cancer agent" refers to a substance or treatment that inhibits the function of cancer cells, inhibits their formation, and/or causes their destruction *in vitro* or *in vivo*. Examples include, but are not limited to, cytotoxic agents (*e.g.*, 5-fluorouracil, TAXOL) and anti-signaling agents (*e.g.*, the PI3K inhibitor LY).

As used herein, the term "cytotoxic agent" refers to a substance that inhibits or prevents the function of cells and/or causes destruction of cells *in vitro* and/or *in vivo*. The term is intended to include radioactive isotopes (*e.g.*, At^{211}, I^{131}, I^{125}, Y^{90}, Re^{186}, Re^{188}, Sm^{153}, Bi^{212}, P^{32}, and radioactive isotopes of Lu), chemotherapeutic agents, toxins such as small molecule toxins or enzymatically active toxins of bacterial, fungal, plant or animal origin, and antibodies, including fragments and/or variants thereof.

As used herein, the term "chemotherapeutic agent" is a chemical compound useful in the treatment of cancer, such as, for example, taxanes, *e.g.*, paclitaxel (TAXOL, BRISTOL-MYERS SQUIBB Oncology, Princeton, N.J.) and doxetaxel (TAXOTERE, Rhone-Poulenc Rorer, Antony, France), chlorambucil, vincristine, vinblastine, anti-estrogens including for example tamoxifen, raloxifene, aromatase inhibiting 4(5)-imidazoles, 4-hydroxytamoxifen, trioxifene, keoxifene, LY117018, onapristone, and toremifene (Fareston), and anti-androgens such as flutamide, nilutamide, bicalutamide, leuprolide, and goserelin, *etc.*

As used herein, the term "anti-signaling agent" refers to agents that interfere with cancer cell malignancy by inhibiting specific aberrant signal transduction circuits in the cell *in vitro* and/or *in vivo*. The PI3K inhibitor LY is an example of an anti-signalling agent.

The terms "comprising", "consisting of" and "consisting essentially of" are defined according to their standard meaning. The terms may be substituted for one

another throughout the instant application in order to attach the specific meaning associated with each term.

As used in this specification and the appended claims, the singular forms "a", "an", and "the" include plural reference unless the context clearly dictates otherwise. Thus, for example, a reference to "a particle" includes more than one such particle, a reference to "a polynucleotide" includes more than one such polynucleotide, a reference to "a polypeptide" includes more than one such polypeptide, a reference to "a host cell" includes more than one such host cell, a reference to an interferon or IFN-inducible molecule includes more than one such interferon or IFN-inducible molecule, and so forth.

Standard molecular biology techniques known in the art and not specifically described were generally followed as in Sambrook *et al.*, Molecular Cloning: A Laboratory Manual, Cold Spring Harbor Laboratory Press, New York (1989), and in Ausubel *et al.*, Current Protocols in Molecular Biology, John Wiley and Sons, Baltimore, Md. (1989) and in Perbal, A Practical Guide to Molecular Cloning, John Wiley & Sons, New York (1988), and in Watson *et al.*, Recombinant DNA, Scientific American Books, New York and in Birren *et al.* (eds) Genome Analysis: A Laboratory Manual Series, Vols. 1-4 Cold Spring Harbor Laboratory Press, New York (1998) and methodology as set forth in U.S. Pat. Nos. 4,666,828; 4,683,202; 4,801,531; 5,192,659; and 5,272,057; and incorporated herein by reference. Polymerase chain reaction (PCR) was carried out generally as in PCR Protocols: A Guide To Methods And Applications, Academic Press, San Diego, Calif. (1990). *In situ* (In-cell) PCR in combination with Flow Cytometry can be used for detection of cells containing specific DNA and mRNA sequences (Testoni *et al.*, *Blood*, 1996, 87:3822).

It should be understood that the examples and embodiments described herein are for illustrative purposes only and that various modifications or changes in light thereof will be suggested to persons skilled in the art and are to be included within the spirit and purview of this application.

Example 1—pIFN-γ induces apoptosis of HEp-2 carcinoma cells

To determine the effect of overexpression of pIFN-γ on proliferation of A549 lung epithelial cells, cells were transfected with either pIFN-γ or empty vector, pVAX

(control). Cell cycle analysis was performed using propidium iodide (PI) staining and flow cytometry 48 hours after transfection. No significant difference was observed between control and pIFN-γ-transfected cells in S1, Go-G1 and G2-M stages of the cell cycle (data not shown). However, an analysis of apoptosis using fluorescence microscopy cells transfected with pIFN-γ exhibited significantly higher apoptosis compared to cells transfected with either the control plasmid or a plasmid encoding pVAX (shown in Figure 1).

Cells were seeded into 4-well slide dishes at 104 cells per well and allowed to grow to 75% confluency. Cells were treated for 20 hours with 1000 U/ml IFN-γ. After 24 hours, cells were fixed with 4% paraformaldehyde in PBS for 25 minutes at 4°C and then permeabilized. Apoptotic cells were identified using a fluorescein-based, terminal nucleotidyl end-labeling kit (PROMEGA TUNEL Apoptosis Assay) that adds fluorescein conjugated dUTP to the 3'-hydroxyl ends of DNA fragments arising from apoptosis. After the reaction, the cells were rinsed in 2x saline citrate buffer and the nuclei were stained with DAPI. Stained cells were examined by immuno-fluorescence microscopy to determine the extent of apoptosis.

Figure 2 demonstrates the detection of p27kip expression and PARP cleavage in IFN-gamma treated HEp-2 cells. Total cell extracts of HEp-2 cells ($1x10^6$) treated as above were prepared after 24 and 48 hours of treatment and proteins were subjected to SDS-PAGE and western blotting was done with a monoclonal antibody to p27kip1 (A) or an antibody to PARP (B). The lanes are as follows: 1) Untreated cells, 2) IFN-gamma 100u/ml, 3) IFN-gamma 1000u/ml, 4) IFN-beta 100u/ml, 5) IFN-beta 1000u/ml, 6) untreated cells, 7) IFN-gamma 100u/ml, 8) IFN-gamma 1000u/ml, 9) IFN-beta 100u/ml, and 10) IFN-beta 1000u/ml.

The apoptosis was confirmed by analysis of PARP cleavage in these cells 48 hours after transfection, which was significantly more prominent in pIFN-γ transfected cells (Figure 2). Thus, pIFN-γ induces apoptosis of lung adenocarcinoma cells. Together, these studies indicate that pIFN-γ is an inducer of apoptosis in A549 lung adenocarcinoma cells.

Example 2—Microarray analysis of Chitosan –pIFNgamma treated lungs

Using MU11KsubA and B chips (Affymetrix), which contain probes interrogating about 11,000 murine genes and ESTs (Unigene, Build-4), as well as EST clusters from TIGR (1.0 Beta), we have identified a total of 126 differentially expressed genes whose expression level is altered in the CIN treated mouse lung in the range of –10.6- to 152.4-fold. A noteworthy observation is the up-regulation of the expression of a number of IFN-inducible genes, immune response related genes, and genes involved in signal transduction, including STAT1 and STAT4.

Table 1. GENE EXPRESSION ANALYSIS IN BALB/c LUNG BY MICROARRAY

Category of Genes	Max. Fold Change	Genes
IFN-regulated	12	IFN-induced 15 KDa protein, IFN-activable protein 204, Eukaryotic initiation factor 5, Mx protein, MIG, IP-10, Interferon regulatory factor (mirf7), interferon-activatable protein, IFN-induced protein 6-16 precursor, IFN-induced guanylate-binding protein, HLA- associated protein i (phapi) 2'-5' oilgo A synthetase
Immune-related	8.4	T-cell specific protein, RegIII gamma protein, MHC class II, MIP, Down regulatory protein (rpt-1r) of interlukin-2, T-cell receptor alpha-chain precursor, Immune-responsive gene 1 (Irg1), High affinity IgG receptor, MHC, class III antigene factor B, MEL-14, Lymphotoxin-beta, C-11, Rantes, MAMA Serine protease, Proteasome subunit (Imp7)
Signal transduction	10.8*	PDGF, GTPase IGTP, Glucocorticoid-attenuated response gene 16, Stat1, purine nucleotide binding protein, G-protein-like LRG-47, ras-related protein ora2, GTP binding protein (IRG-47), Stat 4, cathespin s precursor, Oct binding factor 1 (OBF-1), FYN binding protein, High mobility group 2

The RNA was isolated from BALB/c lungs following 5 days of CIN treatment. The mouse chips A and B, a total of 11,000 genes, were scanned. The asterisk indicates the fold increase was uncertain, as no expression was observed in control lungs. The genes are listed in no particular order.

Example 3—Chitosan-conjugated pIFN-γ plasmid prevents metastasis of lung tumors in nude mice

BALB/c nude mice were injected intravenously with 5 X 10^6 A549 cells, then treated one day afterwards and at weekly intervals with pIFN-γ or control plasmid. After 4 weeks, mice were examined for lung histology. The control animals showed tumors, whereas no tumors were seen in the pIFN-γ-treated group (Figure 3). These results indicate that pIFN-γ has the potential to decrease tumor metastasis.

The results indicated in Figure 3 were obtained when BALB/c nude mice were injected with A549 cells (5 x 10^6 cells/mouse) intravenously and one group treated with pIFN-gamma and another group with pVAX as control. The lungs of control mice showed numerous lung nodules in contrast to mice treated with pIFN-gamma, which showed very few tumors. The lungs were removed from mice treated with nanoparticles carrying empty plasmid pVAX (control) or with pIFN-gamma (Rx) and H & E stained. The lungs of control mice showed numerous lung nodules with typical tumor cell morphology in contrast to mice treated with pIFN-gamma, which showed very few tumors.

Example 4—Development of thermogel from modified chitosan that provides sustained release

Using depolymerization methods, four novel chitosan derivative was synthesized. The products were separated by capillary gel electrophoresis. The plot shows the separation of 2 low molecular weight components (Figure 4A). Nanogene-042(NG042) is a unique low molecular weight chitosan-based carrier, which has a particle size of 155 nm (major peak, with some aggregates at 335 nm), a zeta potential of about +20 mV with typical oligomeric structure, as identified by atomic force microscopy, and significant heat-stable properties for gene transfer, with both *in vitro* and *in vivo* expression (Figures 4B and 4C). Lyophilzed and resuspended NG042 particles retain functionality at ambient temperatures of 23° to 55° C. Nanogene complexes of pGL3 (firefly luciferase, Promega) was lyophilized, reconstituted with water and treated for 24 hours at RT (23° C), 42° C, 55° C, and -20° C. A549 cells were plated and transfected with the above complexes. Uptake and expression of DNA was allowed to occur for 24 hours. Luciferase activity

was determined by using Promega's Dual Assay kit. Readings were normalized to relative luminiscence units (RLU) per mg protein.

Another carrier,Nanogene-044 (NG044), is soluble in water and supports sustained gene expression *in vivo* (Figure 5A). It also exhibits thermo-gelling properties, *i.e.*, it is liquid at room temperature and forms a gel at temperatures above 37°C (Figure 5B). NG045 is a 1000-dalton oligomeric chitosan that is water soluble and shows sustained drug delivery following

NG044 was found to form a gel upon reacting with 2-glycerol phosphate, while NG042, another depolymerized chitosan does not.

To establish length of gene expression, Nanogene 044 (NG044) particles were complexed with DNA (5:1) encoding green fluorescent protein and a hydrogel was formed. The hydrogel was administered intranasally to groups of mice (n=4). Mice were sacrificed on the indicated days and broncho-alveolar lavage cells were examined by fluorescent microscopy. Another group received NG044 with pEGFP without gelling (Control). Gene expression in the mouse lung was measured by EGFP expression in BAL cells 10 and 20 days after administration. The results at day 10 were similar (not shown) for control and hydrogel, whereas after 20 days, mice given hydrogel continued EGFP show expression and no expression was detected in control mice.

Overall, the notion of intranasal chitosan nanoparticles carrying pIFN-γ for the treatment of cancer is based on the preliminary results that pIFN-γ may induce epithelial cell production of NO, which is known to possess anti-tumor effects, apoptosis of carcinoma cells, and abrogation of lung nodule formation in a murine model of lung metastasis. It will be seen that the objects set forth above, and those made apparent from the foregoing description, are efficiently attained and since certain changes may be made in the above construction without departing from the scope of the invention, it is intended that all matters contained in the foregoing description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

All patents, patent applications, provisional applications, and publications (including information associated with sequence accession numbers) referred to or cited herein are incorporated by reference in their entirety, including all figures and tables, to the extent they are not inconsistent with the explicit teachings of this specification.

CLAIMS

I claim:

1. A method for treating a cell proliferation disorder in a subject, comprising administering a therapeutically effective amount of particles to the subject, wherein the particles comprise: a polynucleotide encoding an interferon, an interferon-inducible molecule, or both; and a chitin-containing component associated with the polynucleotide, wherein the polynucleotide is expressed in the subject and cell proliferation is reduced.

2. The method of claim 1, wherein the interferon is selected from the group consisting of alpha interferon, beta interferon, gamma interferon, omega interferon, and lambda interferon, or a biologically active fragment or derivative thereof.

3. The method of claim 1, wherein the interferon is gamma interferon.

4. The method of claim 1, wherein the interferon is a hybrid interferon.

5. The method of claim 1, wherein the interferon inducible molecule comprises interferon regulatory factor-1 (IRF-1).

6. The method of claim 1, wherein the interferon-inducible molecule comprises 2'-5' oligoadenylate synthetase, interferon regulatory factor-1 (IRF-1), or both.

7. The method of claim 1, wherein the interferon-inducible molecule comprises a catalytically active subunit of 2'-5' oligoadenylate synthetase selected from the group consisting of p40, p69, and p100 subunit.

8. The method of claim 1, wherein the 2'-5' oligoadenylate synthetase comprises at least one splice variant selected from the group consisting of 40kDa, 42kDa, 46kDa, 69 kDa, and 71 kDa.

9. The method of claim 1, wherein the chitin-containing component comprises chitosan or a chitosan derivative.

10. The method of claim 1, wherein the particles further comprise a lipid component associated with the chitin-containing component and the polynucleotide.

11. The method of claim 1, wherein the cell proliferation disorder is a cancer of the respiratory tract.

12. The method of claim 1, wherein the cell proliferation disorder is lung cancer.

13. The method of claim 1, wherein the particles are administered to the subject via a mucosal route.

14. The method of claim 1, wherein the particles are administered to the subject intranasally.

15. The method of claim 1, wherein the particles are administered to the subject as a spray, drops, powder, gel, or a combination of two or more of the foregoing.

16. The method of claim 1, wherein the subject is human.

17. The method of claim 1, wherein the subject is suffering from a cell proliferation disorder.

18. The method of claim 1, wherein the subject has been diagnosed with the cell proliferation disorder prior to said administering.

19. A method of inducing apoptosis in a cancer cell, comprising contacting a target cancer cell *in vitro* or *in vivo* with an effective amount of particles comprising: a polynucleotide encoding an interferon, an interferon-inducible molecule, or both; and a

chitin-containing component associated with the polynucleotide, wherein the polynucleotide is expressed in the cancer cell and apoptosis is induced.

20. The method of claim 19, wherein the interferon is selected from the group consisting of alpha interferon, beta interferon, gamma interferon, omega interferon, and lambda interferon, or a biologically active fragment or derivative thereof.

21. The method of claim 19, wherein the interferon-inducible molecule comprises 2'-5' oligoadenylate synthetase, interferon regulatory factor-1 (IRF-1), or both.

22. The method of claim 19, wherein the cancer cell is a respiratory epithelial cell.

23. A particle comprising a polynucleotide encoding an interferon, an interferon-inducible molecule, or both; and a chitin-containing component associated with the polynucleotide.

24. The particle of claim 23, wherein said chitin-containing component comprises chitosan or a chitosan derivative.

25. The particle of claim 23, wherein said particle further comprises a lipid component associated with the chitin-containing component and the polynucleotide.

26. The particle of claim 23, wherein said particle comprises a polynucleotide encoding said interferon and said interferon-inducible molecule.

27. The particle of claim 23, wherein said particle comprises a polynucleotide encoding said interferon and 2'-5' oligoadenylate synthetase.

28. The particle of claim 23, wherein said particle comprises a polynucleotide encoding said interferon and interferon regulatory factor-1 (IRF-1).

29. The particle of claim 23, wherein said particle comprises a polynucleotide encoding 2'-5' oligoadenylate synthetase and interferon regulatory factor-1 (IRF-1).

30. The particle of claim 23, wherein said particle comprises a polynucleotide encoding said interferon, 2'-5' oligoadenylate synthetase, and interferon regulatory factor-1 (IRF-1).

31. The particle of claim 23, wherein said polynucleotide comprises one or more nucleotide sequences selected from the group consisting of SEQ ID NOs: 1, 3, 5, 7, 9, 11, 13, 14, 15, 16, 17, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, and 31.

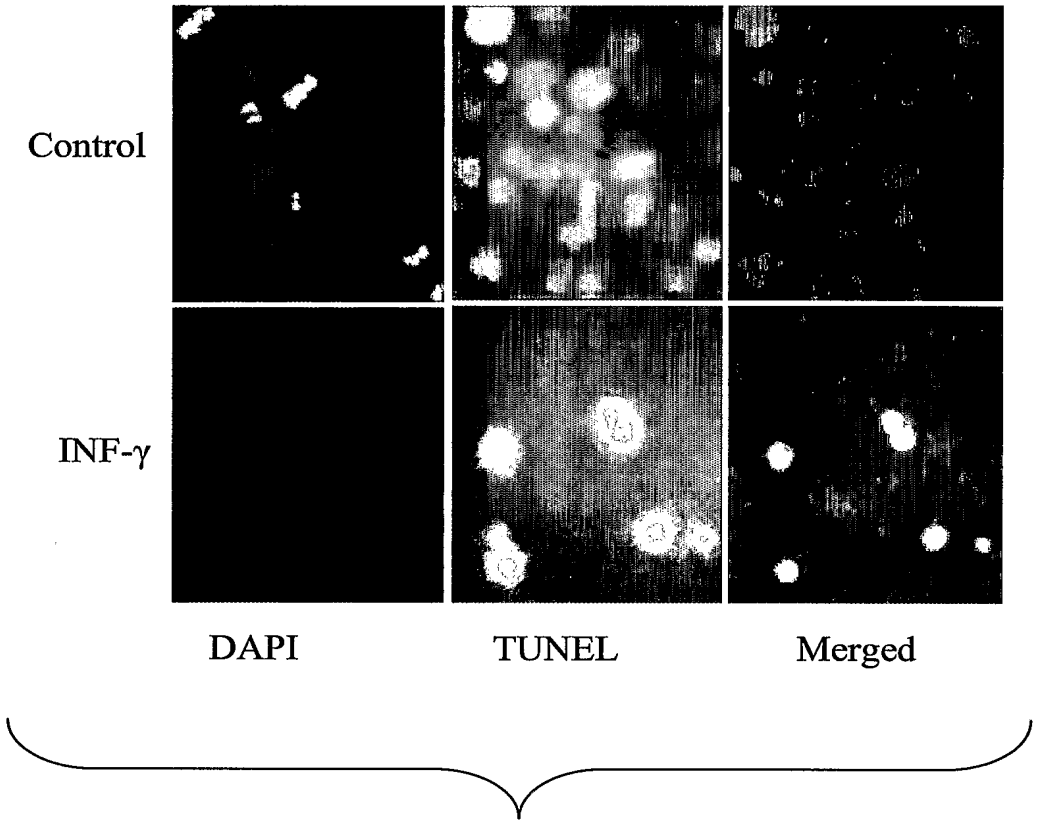


FIG. 1

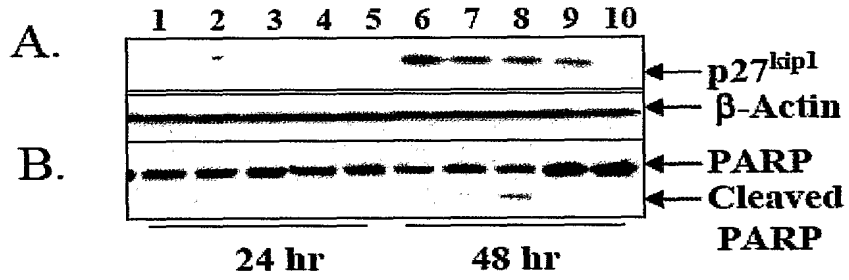
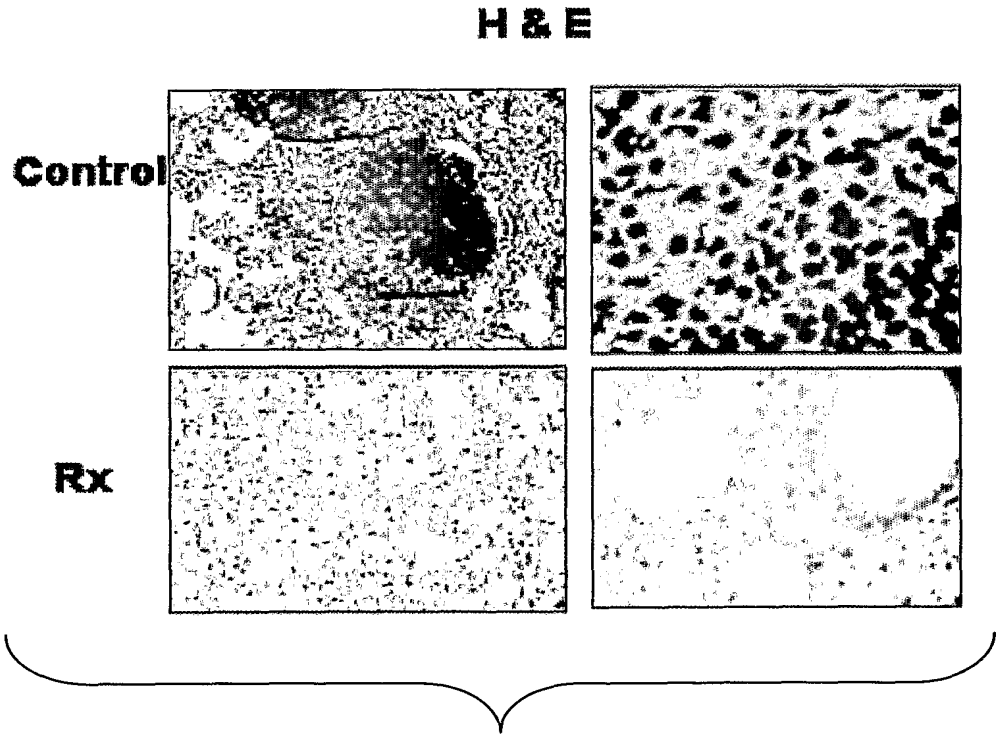

A.
B.
1 2 3 4 5 6 7 8 9 10
p27kip1
β-Actin
PARP
Cleaved PARP
24 hr
48 hr

FIG. 2


H & E
Control
Rx

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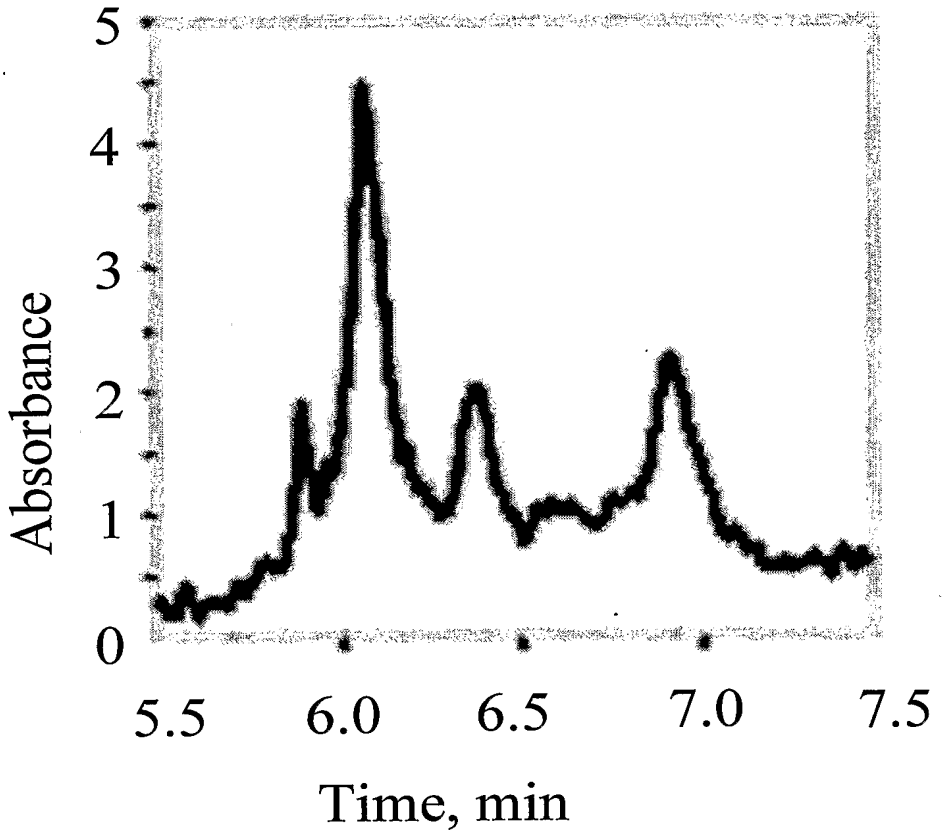

FIG. 4A

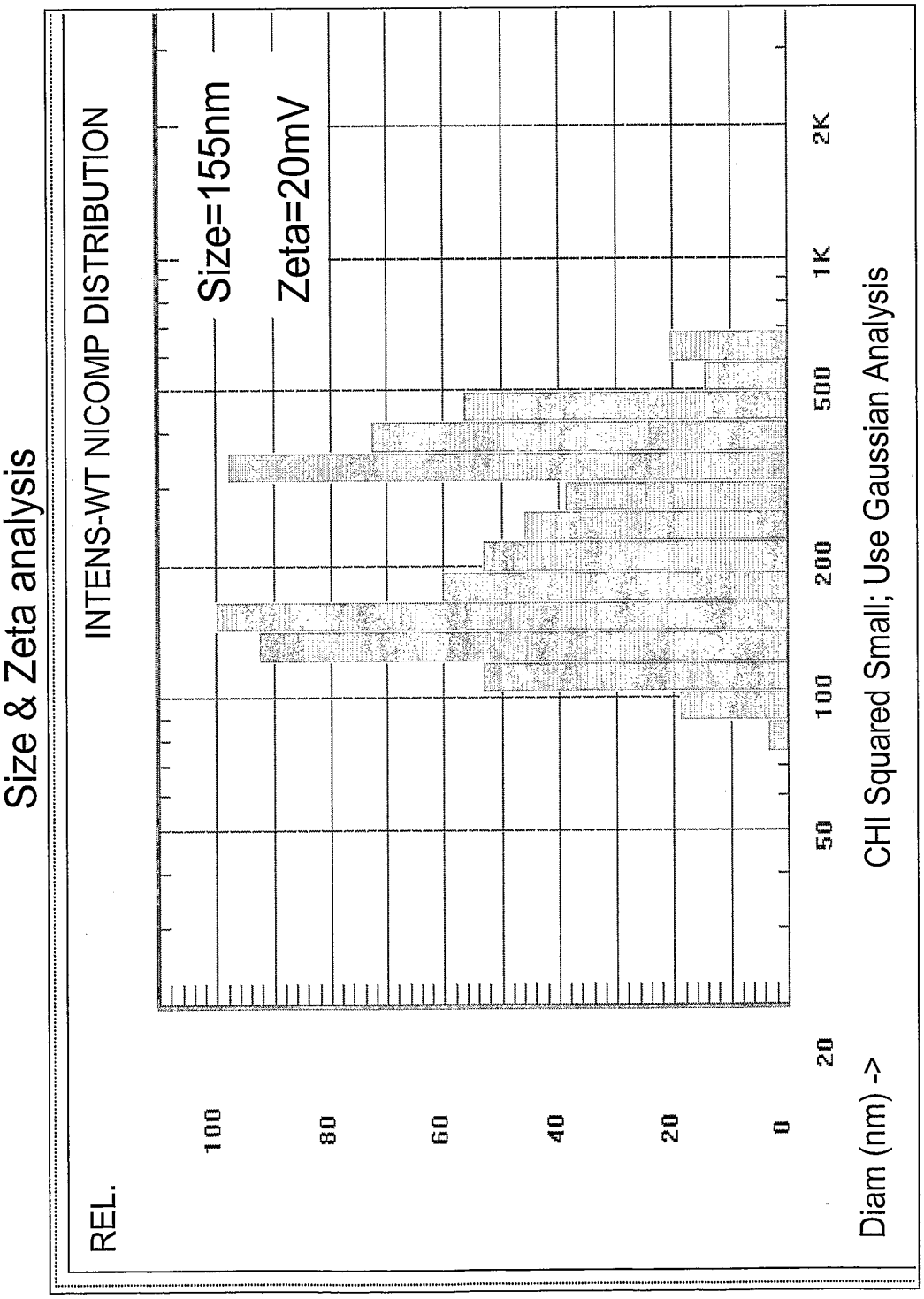
Size & Zeta analysis
INTENS-WT NICOMP DISTRIBUTION
REL.
Size=155nm
Zeta=20mV
100
80
60
40
20
0
20
50
100
200
500
1K
2K
Diam (nm) ->
CHI Squared Small; Use Gaussian Analysis

FIG. 4B

AFM analysis

FIG. 4C

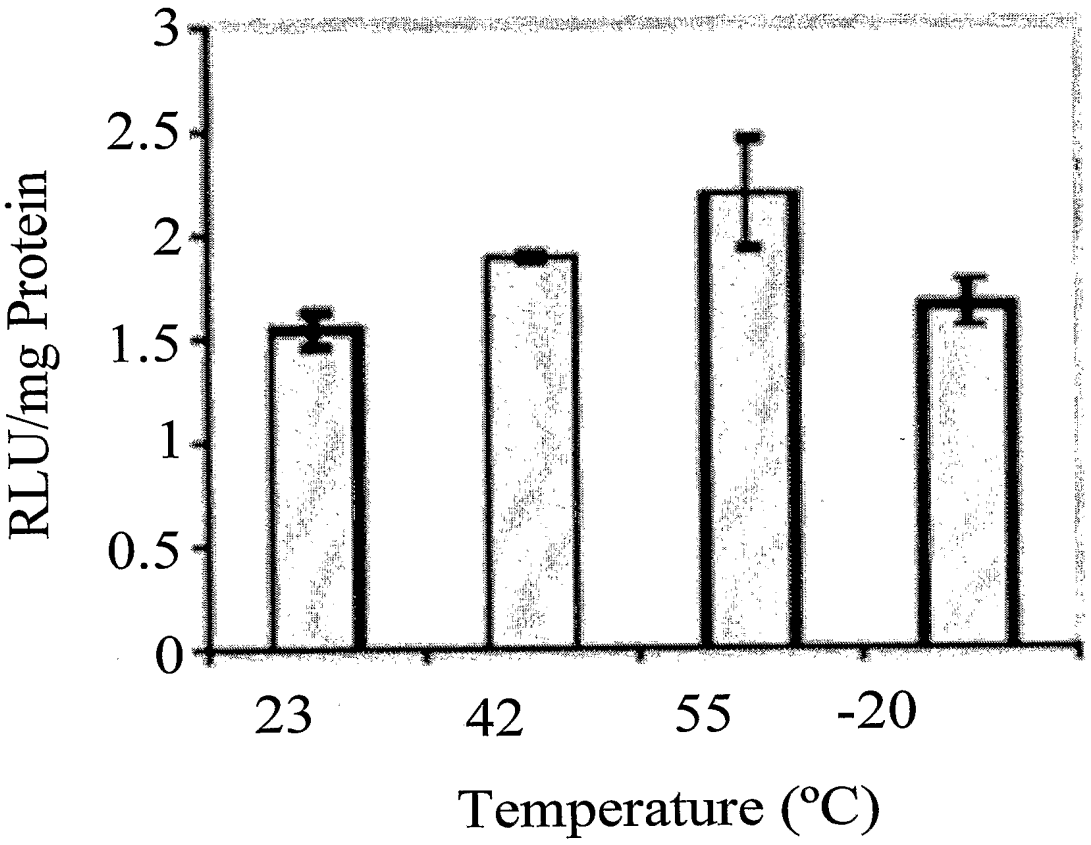

FIG. 4D

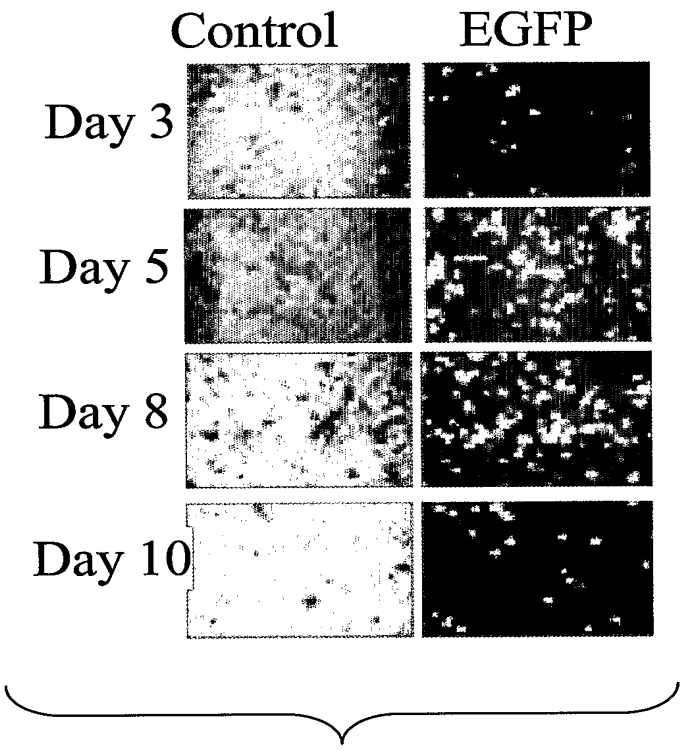

FIG. 5A

Thermogelling

NG042 NG044

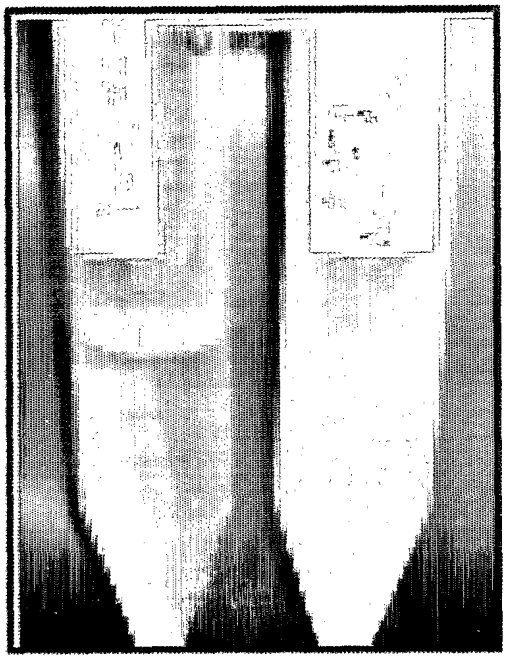

FIG. 5B

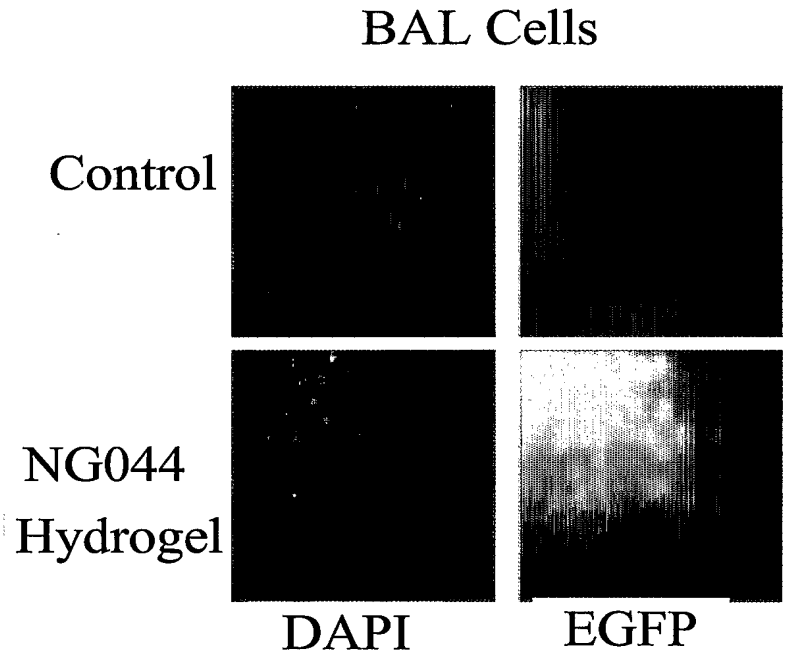

FIG. 5C

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<309> 2003-04-06

<300>
<301> Merlin, G., et al.
<302> Molecular cloning and sequence of partial cDNA for interferon-induced (2'-5')oligo(A_ synthetase mRNA from human cells
<303> Proc. Natl. Acad. Sci. U.S.A.
<304> 80
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<306> 4904-4908
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gcc att gac atc atc tgt ggg ttc ctg aag gaa agg tgc ttc cga ggt      144
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agc tcc tac cct gtg tgt gtg tcc aag gtg gta aag ggt ggc tcc tca      192
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50                  55                  60

ggc aag ggc acc acc ctc aga ggc cga tct gac gct gac ctg gtt gtc      240
Gly Lys Gly Thr Thr Leu Arg Gly Arg Ser Asp Ala Asp Leu Val Val
65                  70                  75                  80

ttc ctc agt cct ctc acc act ttt cag gat cag tta aat cgc cgg gga      288
Phe Leu Ser Pro Leu Thr Thr Phe Gln Asp Gln Leu Asn Arg Arg Gly
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gag ttc atc cag gaa att agg aga cag ctg gaa gcc tgt caa aga gag      336
Glu Phe Ile Gln Glu Ile Arg Arg Gln Leu Glu Ala Cys Gln Arg Glu
            100                 105                 110

aga gca ctt tcc gtg aag ttt gag gtc cag gct cca cgc tgg ggc aac      384
Arg Ala Leu Ser Val Lys Phe Glu Val Gln Ala Pro Arg Trp Gly Asn
        115                 120                 125

ccc cgt gcg ctc agc ttc gta ctg agt tcg ctc cag ctc ggg gag ggg      432
Pro Arg Ala Leu Ser Phe Val Leu Ser Ser Leu Gln Leu Gly Glu Gly
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gtg gag ttc gat gtg ctg cct gcc ttt gat gcc ctg ggt cag ttg act      480
Val Glu Phe Asp Val Leu Pro Ala Phe Asp Ala Leu Gly Gln Leu Thr
145                 150                 155                 160

ggc agc tat aaa cct aac ccc caa atc tat gtc aag ctc atc gag gag      528
Gly Ser Tyr Lys Pro Asn Pro Gln Ile Tyr Val Lys Leu Ile Glu Glu
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tgc acc gac ctg cag aaa gag ggc gag ttc tcc acc tgc ttc aca gaa      576
Cys Thr Asp Leu Gln Lys Glu Gly Glu Phe Ser Thr Cys Phe Thr Glu
            180                 185                 190

cta cag aga gac ttc ctg aag cag cgc ccc acc aag ctc aag agc ctc      624
Leu Gln Arg Asp Phe Leu Lys Gln Arg Pro Thr Lys Leu Lys Ser Leu
        195                 200                 205

atc cgc cta gtc aag cac tgg tac caa aat tgt aag aag aag ctt ggg      672
Ile Arg Leu Val Lys His Trp Tyr Gln Asn Cys Lys Lys Lys Leu Gly
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225                 230                 235                 240

gag cga ggg agc atg aaa aca cat ttc aac aca gcc caa gga ttt cgg      768
Glu Arg Gly Ser Met Lys Thr His Phe Asn Thr Ala Gln Gly Phe Arg
                245                 250                 255

acg gtc ttg gaa tta gtc ata aac tac cag caa ctc tgc atc tac tgg      816
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agg cag ctc acg aaa ccc agg cct gtg atc ctg gac ccg gcg gac cct      912
Arg Gln Leu Thr Lys Pro Arg Pro Val Ile Leu Asp Pro Ala Asp Pro
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aca gga aac ttg ggt ggt gga gac cca aag ggt tgg agg cag ctg gca      960
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caa gag gct gag gcc tgg ctg aat tac cca tgc ttt aag aat tgg gat     1008
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Gly Thr His Glu Tyr Pro His Phe Ser His Arg Pro Ser Thr Leu Gln
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tga                                                                 1203


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Ala Ile Asp Ile Ile Cys Gly Phe Leu Lys Glu Arg Cys Phe Arg Gly
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Ser Ser Tyr Pro Val Cys Val Ser Lys Val Val Lys Gly Gly Ser Ser
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Phe Leu Ser Pro Leu Thr Thr Phe Gln Asp Gln Leu Asn Arg Arg Gly
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Glu Phe Ile Gln Glu Ile Arg Arg Gln Leu Glu Ala Cys Gln Arg Glu
            100                 105                 110

Arg Ala Leu Ser Val Lys Phe Glu Val Gln Ala Pro Arg Trp Gly Asn
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Pro Arg Ala Leu Ser Phe Val Leu Ser Ser Leu Gln Leu Gly Glu Gly
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Val Glu Phe Asp Val Leu Pro Ala Phe Asp Ala Leu Gly Gln Leu Thr
145                 150                 155                 160

Gly Ser Tyr Lys Pro Asn Pro Gln Ile Tyr Val Lys Leu Ile Glu Glu
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Cys Thr Asp Leu Gln Lys Glu Gly Glu Phe Ser Thr Cys Phe Thr Glu
            180                 185                 190

Leu Gln Arg Asp Phe Leu Lys Gln Arg Pro Thr Lys Leu Lys Ser Leu
        195                 200                 205

Ile Arg Leu Val Lys His Trp Tyr Gln Asn Cys Lys Lys Lys Leu Gly
    210                 215                 220

Lys Leu Pro Pro Gln Tyr Ala Leu Glu Leu Leu Thr Val Tyr Ala Trp
225                 230                 235                 240

Glu Arg Gly Ser Met Lys Thr His Phe Asn Thr Ala Gln Gly Phe Arg
                245                 250                 255

Thr Val Leu Glu Leu Val Ile Asn Tyr Gln Gln Leu Cys Ile Tyr Trp
            260                 265                 270

Thr Lys Tyr Tyr Asp Phe Lys Asn Pro Ile Ile Glu Lys Tyr Leu Arg
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Arg Gln Leu Thr Lys Pro Arg Pro Val Ile Leu Asp Pro Ala Asp Pro
    290                 295                 300
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                325                 330                 335

Gly Ser Pro Val Ser Ser Trp Ile Leu Leu Ala Glu Ser Asn Ser Thr
            340                 345                 350

Asp Asp Glu Thr Asp Asp Pro Arg Thr Tyr Gln Lys Tyr Gly Tyr Ile
        355                 360                 365

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385                 390                 395                 400
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<302> Structure of two forms of the interferon-induced (2'-5') oligo A synthetase human cells based on cDNAs and gene sequences
<303> EMBO J.
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gaa gac tat ctc ttg cca gac acg tgt ttc cgc atg caa atc gac cat       96
Glu Asp Tyr Leu Leu Pro Asp Thr Cys Phe Arg Met Gln Ile Asp His
            20                  25                  30

gcc att gac atc atc tgt ggg ttc ctg aag gaa agg tgc ttc cga ggt      144
Ala Ile Asp Ile Ile Cys Gly Phe Leu Lys Glu Arg Cys Phe Arg Gly
        35                  40                  45
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agc tcc tac cct gtg tgt gtg tcc aag gtg gta aag ggt ggc tcc tca      192
Ser Ser Tyr Pro Val Cys Val Ser Lys Val Val Lys Gly Gly Ser Ser
    50                  55                  60

ggc aag ggc acc acc ctc aga ggc cga tct gac gct gac ctg gtt gtc      240
Gly Lys Gly Thr Thr Leu Arg Gly Arg Ser Asp Ala Asp Leu Val Val
65                  70                  75                  80

ttc ctc agt cct ctc acc act ttt cag gat cag tta aat cgc cgg gga      288
Phe Leu Ser Pro Leu Thr Thr Phe Gln Asp Gln Leu Asn Arg Arg Gly
                85                  90                  95

gag ttc atc cag gaa att agg aga cag ctg gaa gcc tgt caa aga gag      336
Glu Phe Ile Gln Glu Ile Arg Arg Gln Leu Glu Ala Cys Gln Arg Glu
            100                 105                 110

aga gca ctt tcc gtg aag ttt gag gtc cag gct cca cgc tgg ggc aac      384
Arg Ala Leu Ser Val Lys Phe Glu Val Gln Ala Pro Arg Trp Gly Asn
        115                 120                 125

ccc cgt gcg ctc agc ttc gta ctg agt tcg ctc cag ctc ggg gag ggg      432
Pro Arg Ala Leu Ser Phe Val Leu Ser Ser Leu Gln Leu Gly Glu Gly
    130                 135                 140

gtg gag ttc gat gtg ctg cct gcc ttt gat gcc ctg ggt cag ttg act      480
Val Glu Phe Asp Val Leu Pro Ala Phe Asp Ala Leu Gly Gln Leu Thr
145                 150                 155                 160

ggc agc tat aaa cct aac ccc caa atc tat gtc aag ctc atc gag gag      528
Gly Ser Tyr Lys Pro Asn Pro Gln Ile Tyr Val Lys Leu Ile Glu Glu
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tgc acc gac ctg cag aaa gag ggc gag ttc tcc acc tgc ttc aca gaa      576
Cys Thr Asp Leu Gln Lys Glu Gly Glu Phe Ser Thr Cys Phe Thr Glu
            180                 185                 190

cta cag aga gac ttc ctg aag cag cgc ccc acc aag ctc aag agc ctc      624
Leu Gln Arg Asp Phe Leu Lys Gln Arg Pro Thr Lys Leu Lys Ser Leu
        195                 200                 205

atc cgc cta gtc aag cac tgg tac caa aat tgt aag aag aag ctt ggg      672
Ile Arg Leu Val Lys His Trp Tyr Gln Asn Cys Lys Lys Lys Leu Gly
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aag ctg cca cct cag tat gcc ctg gag ctc ctg acg gtc tat gct tgg      720
Lys Leu Pro Pro Gln Tyr Ala Leu Glu Leu Leu Thr Val Tyr Ala Trp
225                 230                 235                 240

gag cga ggg agc atg aaa aca cat ttc aac aca gcc caa gga ttt cgg      768
Glu Arg Gly Ser Met Lys Thr His Phe Asn Thr Ala Gln Gly Phe Arg
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acg gtc ttg gaa tta gtc ata aac tac cag caa ctc tgc atc tac tgg      816
Thr Val Leu Glu Leu Val Ile Asn Tyr Gln Gln Leu Cys Ile Tyr Trp
            260                 265                 270

aca aag tat tat gac ttt aaa aac ccc att att gaa aag tac ctg aga      864
Thr Lys Tyr Tyr Asp Phe Lys Asn Pro Ile Ile Glu Lys Tyr Leu Arg
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        275                 280                 285

agg cag ctc acg aaa ccc agg cct gtg atc ctg gac ccg gcg gac cct      912
Arg Gln Leu Thr Lys Pro Arg Pro Val Ile Leu Asp Pro Ala Asp Pro
    290                 295                 300

aca gga aac ttg ggt ggt gga gac cca aag ggt tgg agg cag ctg gca      960
Thr Gly Asn Leu Gly Gly Gly Asp Pro Lys Gly Trp Arg Gln Leu Ala
305                 310                 315                 320

caa gag gct gag gcc tgg ctg aat tac cca tgc ttt aag aat tgg gat     1008
Gln Glu Ala Glu Ala Trp Leu Asn Tyr Pro Cys Phe Lys Asn Trp Asp
                325                 330                 335

ggg tcc cca gtg agc tcc tgg att ctg ctg gct gaa agc aac agt aca     1056
Gly Ser Pro Val Ser Ser Trp Ile Leu Leu Ala Glu Ser Asn Ser Thr
            340                 345                 350

gac gat gag acc gac gat ccc agg acg tat cag aaa tat ggt tac att     1104
Asp Asp Glu Thr Asp Asp Pro Arg Thr Tyr Gln Lys Tyr Gly Tyr Ile
        355                 360                 365

gga aca cat gag tac cct cat ttc tct cat aga ccc agc acg ctc cag     1152
Gly Thr His Glu Tyr Pro His Phe Ser His Arg Pro Ser Thr Leu Gln
    370                 375                 380

gca gca tcc acc cca cag gca gaa gag gac tgg acc tgc acc atc ctc     1200
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385                 390                 395                 400

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Ala Ile Asp Ile Ile Cys Gly Phe Leu Lys Glu Arg Cys Phe Arg Gly
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Glu Phe Ile Gln Glu Ile Arg Arg Gln Leu Glu Ala Cys Gln Arg Glu
100 105 110

Arg Ala Leu Ser Val Lys Phe Glu Val Gln Ala Pro Arg Trp Gly Asn
115 120 125

Pro Arg Ala Leu Ser Phe Val Leu Ser Ser Leu Gln Leu Gly Glu Gly
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Val Glu Phe Asp Val Leu Pro Ala Phe Asp Ala Leu Gly Gln Leu Thr
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Gly Ser Tyr Lys Pro Asn Pro Gln Ile Tyr Val Lys Leu Ile Glu Glu
165 170 175

Cys Thr Asp Leu Gln Lys Glu Gly Glu Phe Ser Thr Cys Phe Thr Glu
180 185 190

Leu Gln Arg Asp Phe Leu Lys Gln Arg Pro Thr Lys Leu Lys Ser Leu
195 200 205

Ile Arg Leu Val Lys His Trp Tyr Gln Asn Cys Lys Lys Lys Leu Gly
210 215 220

Lys Leu Pro Pro Gln Tyr Ala Leu Glu Leu Leu Thr Val Tyr Ala Trp
225 230 235 240

Glu Arg Gly Ser Met Lys Thr His Phe Asn Thr Ala Gln Gly Phe Arg
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Thr Val Leu Glu Leu Val Ile Asn Tyr Gln Gln Leu Cys Ile Tyr Trp
260 265 270

Thr Lys Tyr Tyr Asp Phe Lys Asn Pro Ile Ile Glu Lys Tyr Leu Arg
275 280 285

Arg Gln Leu Thr Lys Pro Arg Pro Val Ile Leu Asp Pro Ala Asp Pro
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Gly Ser Pro Val Ser Ser Trp Ile Leu Leu Ala Glu Ser Asn Ser Thr
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<301> Hovnanian, A., et al.
<302> The human 2', 5'-oligoadenylate synthetase locus is comosed of three distinct genes
<303> Genomics
<304> 52
<305> 3
<306> 267-277
<307> 1998
<308> NCBI/NM_002535
<309> 2003-04-03

<300>
<301> Marie, I. and Hovanessian, A.G.
<302> The 69-kDa 2-5A synthetase is composed of two homologous and adjacent functional domains
<303> J. Biol. Chem.
<304> 267
<305> 14
<306> 9933-9939
<307> 1992
<308> NCBI/NM_002535
<309> 2003-04-03

<300>

<301> Marie, I., et al.
<302> Differential expression and distinct structure of 69- and 100-kDa forms of 2-5A synthetase
<303> J. Biol. Chem.
<304> 265
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<306> 18601-18607
<307> 1990
<308> NCBI/NM_002535
<309> 2003-04-03

<300>
<301> Marie, I., et al.
<302> Preparation and characterization of polyclonal antibodies specific for the 69 and 100 k-dalton forms of human 2-5A synthetase
<303> Biochem. Biophys. Res. Commun.
<304> 160
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<306> 580-587
<307> 1989
<308> NCBI/NM_002535
<309> 2003-04-03

<300>
<301> Hovanessian, A.G., et al.
<302> Characterization of 69- and 100-kDa forms of 2-5A-synthetase from interferon-treated human cells
<303> J. Biol. Chem.
<304> 263
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<306> 4959
<307> 1988
<308> NCBI/NM_002535
<309> 2003-04-03

<300>
<301> Hovanessian, A.G., et al.
<302> Identification of 69-kd and 100-kd forms of 2-5A synthesase
<303> EMBO J.
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1               5                   10                  15

ggt tgg ttt atc cag gaa tac ctg aag ccc tac gaa gaa tgt cag aca       96
Gly Trp Phe Ile Gln Glu Tyr Leu Lys Pro Tyr Glu Glu Cys Gln Thr
            20                  25                  30

ctg atc gac gag atg gtg aac acc atc tgt gac gtc tgc agg aac ccc      144
Leu Ile Asp Glu Met Val Asn Thr Ile Cys Asp Val Cys Arg Asn Pro
        35                  40                  45
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gaa cag ttc ccc ctg gtg cag gga gtg gcc ata ggt ggc tcc tat gga      192
Glu Gln Phe Pro Leu Val Gln Gly Val Ala Ile Gly Gly Ser Tyr Gly
    50                  55                  60

cgg aaa aca gtc tta aga ggc aac tcc gat ggt acc ctt gtc ctt ttc      240
Arg Lys Thr Val Leu Arg Gly Asn Ser Asp Gly Thr Leu Val Leu Phe
65                  70                  75                  80

ttc agt gac tta aaa caa ttc cag gat cag aag aga agc caa cgt gac      288
Phe Ser Asp Leu Lys Gln Phe Gln Asp Gln Lys Arg Ser Gln Arg Asp
                85                  90                  95

atc ctc gat aaa act ggg gat aag ctg aag ttc tgt ctg ttc acg aag      336
Ile Leu Asp Lys Thr Gly Asp Lys Leu Lys Phe Cys Leu Phe Thr Lys
            100                 105                 110

tgg ttg aaa aac aat ttc gag atc cag aag tcc ctt gat ggg tcc acc      384
Trp Leu Lys Asn Asn Phe Glu Ile Gln Lys Ser Leu Asp Gly Ser Thr
        115                 120                 125

atc cag gtg ttc aca aaa aat cag aga atc tct ttc gag gtg ctg gcc      432
Ile Gln Val Phe Thr Lys Asn Gln Arg Ile Ser Phe Glu Val Leu Ala
    130                 135                 140

gcc ttc aac gct ctg agc tta aat gat aat ccc agc ccc tgg atc tat      480
Ala Phe Asn Ala Leu Ser Leu Asn Asp Asn Pro Ser Pro Trp Ile Tyr
145                 150                 155                 160

cga gag ctc aaa aga tcc ttg gat aag aca aat gcc agt cct ggt gag      528
Arg Glu Leu Lys Arg Ser Leu Asp Lys Thr Asn Ala Ser Pro Gly Glu
                165                 170                 175

ttt gca gtc tgc ttc act gaa ctc cag cag aag ttt ttt gac aac cgt      576
Phe Ala Val Cys Phe Thr Glu Leu Gln Gln Lys Phe Phe Asp Asn Arg
            180                 185                 190

cct gga aaa cta aag gat ttg atc ctc ttg ata aag cac tgg cat caa      624
Pro Gly Lys Leu Lys Asp Leu Ile Leu Leu Ile Lys His Trp His Gln
        195                 200                 205

cag tgc cag aaa aaa atc aag gat tta ccc tcg ctg tct ccg tat gcc      672
Gln Cys Gln Lys Lys Ile Lys Asp Leu Pro Ser Leu Ser Pro Tyr Ala
    210                 215                 220

ctg gag ctg ctt acg gtg tat gcc tgg gaa cag ggg tgc aga aaa gac      720
Leu Glu Leu Leu Thr Val Tyr Ala Trp Glu Gln Gly Cys Arg Lys Asp
225                 230                 235                 240

aac ttt gac att gct gaa ggc gtc aga acg gtt ctg gag ctg atc aaa      768
Asn Phe Asp Ile Ala Glu Gly Val Arg Thr Val Leu Glu Leu Ile Lys
                245                 250                 255

tgc cag gag aag ctg tgt atc tat tgg atg gtc aac tac aac ttt gaa      816
Cys Gln Glu Lys Leu Cys Ile Tyr Trp Met Val Asn Tyr Asn Phe Glu
            260                 265                 270

gat gag acc atc agg aac atc ctg ctg cac cag ctc caa tca gcg agg      864
Asp Glu Thr Ile Arg Asn Ile Leu Leu His Gln Leu Gln Ser Ala Arg
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        275                 280                 285

cca gta atc ttg gat cca gtt gac cca acc aat aat gtg agt gga gat      912
Pro Val Ile Leu Asp Pro Val Asp Pro Thr Asn Asn Val Ser Gly Asp
    290                 295                 300

aaa ata tgc tgg caa tgg ctg aaa aaa gaa gct caa acc tgg ttg act      960
Lys Ile Cys Trp Gln Trp Leu Lys Lys Glu Ala Gln Thr Trp Leu Thr
305                 310                 315                 320

tct ccc aac ctg gat aat gag tta cct gca cca tct tgg aat gtc ctg     1008
Ser Pro Asn Leu Asp Asn Glu Leu Pro Ala Pro Ser Trp Asn Val Leu
                325                 330                 335

cct gca cca ctc ttc acg acc cca ggc cac ctt ctg gat aag ttc atc     1056
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            340                 345                 350

aag gag ttt ctc cag ccc aac aaa tgc ttc cta gag cag att gac agt     1104
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    370                 375                 380

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385                 390                 395                 400

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cga aac ttc att cgc tcc cgg ccc acc aaa cta aag gat tta att cgc     1632
Arg Asn Phe Ile Arg Ser Arg Pro Thr Lys Leu Lys Asp Leu Ile Arg
    530                 535                 540

ctg gtg aag cac tgg tac aaa gag tgt gaa agg aaa ctg aag cca aag     1680
Leu Val Lys His Trp Tyr Lys Glu Cys Glu Arg Lys Leu Lys Pro Lys
545                 550                 555                 560

ggg tct ttg ccc cca aag tat gcc ttg gag ctg ctc acc atc tat gcc     1728
Gly Ser Leu Pro Pro Lys Tyr Ala Leu Glu Leu Leu Thr Ile Tyr Ala
                565                 570                 575

tgg gag cag ggg agt gga gtg ccg gat ttt gac act gca gaa ggt ttc     1776
Trp Glu Gln Gly Ser Gly Val Pro Asp Phe Asp Thr Ala Glu Gly Phe
            580                 585                 590

cgg aca gtc ctg gag ctg gtc aca caa tat cag cag ctc ggc atc ttc     1824
Arg Thr Val Leu Glu Leu Val Thr Gln Tyr Gln Gln Leu Gly Ile Phe
        595                 600                 605

tgg aag gtc aat tac aac ttt gaa gat gag acc gtg agg aag ttt cta     1872
Trp Lys Val Asn Tyr Asn Phe Glu Asp Glu Thr Val Arg Lys Phe Leu
    610                 615                 620

ctg agc cag ttg cag aaa acc agg cct gtg atc ttg gac cca ggc gaa     1920
Leu Ser Gln Leu Gln Lys Thr Arg Pro Val Ile Leu Asp Pro Gly Glu
625                 630                 635                 640

ccc aca ggt gac gtg ggt gga ggg gac cgt tgg tgt tgg cat ctt ctg     1968
Pro Thr Gly Asp Val Gly Gly Gly Asp Arg Trp Cys Trp His Leu Leu
                645                 650                 655

gac aaa gaa gca aag gtt agg tta tcc tct ccc tgc ttc aag gat ggg     2016
Asp Lys Glu Ala Lys Val Arg Leu Ser Ser Pro Cys Phe Lys Asp Gly
            660                 665                 670

act gga aac cca ata cca cct tgg aaa gtg ccg gta aaa gtc atc taa     2064
Thr Gly Asn Pro Ile Pro Pro Trp Lys Val Pro Val Lys Val Ile
        675                 680                 685


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Leu Ile Asp Glu Met Val Asn Thr Ile Cys Asp Val Cys Arg Asn Pro
        35                  40                  45

Glu Gln Phe Pro Leu Val Gln Gly Val Ala Ile Gly Gly Ser Tyr Gly
    50                  55                  60

Arg Lys Thr Val Leu Arg Gly Asn Ser Asp Gly Thr Leu Val Leu Phe
65                  70                  75                  80

Phe Ser Asp Leu Lys Gln Phe Gln Asp Gln Lys Arg Ser Gln Arg Asp
                85                  90                  95

Ile Leu Asp Lys Thr Gly Asp Lys Leu Lys Phe Cys Leu Phe Thr Lys
            100                 105                 110

Trp Leu Lys Asn Asn Phe Glu Ile Gln Lys Ser Leu Asp Gly Ser Thr
        115                 120                 125

Ile Gln Val Phe Thr Lys Asn Gln Arg Ile Ser Phe Glu Val Leu Ala
    130                 135                 140

Ala Phe Asn Ala Leu Ser Leu Asn Asp Asn Pro Ser Pro Trp Ile Tyr
145                 150                 155                 160

Arg Glu Leu Lys Arg Ser Leu Asp Lys Thr Asn Ala Ser Pro Gly Glu
                165                 170                 175

Phe Ala Val Cys Phe Thr Glu Leu Gln Gln Lys Phe Phe Asp Asn Arg
            180                 185                 190

Pro Gly Lys Leu Lys Asp Leu Ile Leu Leu Ile Lys His Trp His Gln
        195                 200                 205

Gln Cys Gln Lys Lys Ile Lys Asp Leu Pro Ser Leu Ser Pro Tyr Ala
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Leu Glu Leu Leu Thr Val Tyr Ala Trp Glu Gln Gly Cys Arg Lys Asp
225                 230                 235                 240

Asn Phe Asp Ile Ala Glu Gly Val Arg Thr Val Leu Glu Leu Ile Lys
                245                 250                 255

Cys Gln Glu Lys Leu Cys Ile Tyr Trp Met Val Asn Tyr Asn Phe Glu
            260                 265                 270
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Asp Glu Thr Ile Arg Asn Ile Leu Leu His Gln Leu Gln Ser Ala Arg
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Pro Val Ile Leu Asp Pro Val Asp Pro Thr Asn Asn Val Ser Gly Asp
    290                 295                 300

Lys Ile Cys Trp Gln Trp Leu Lys Lys Glu Ala Gln Thr Trp Leu Thr
305                 310                 315                 320

Ser Pro Asn Leu Asp Asn Glu Leu Pro Ala Pro Ser Trp Asn Val Leu
                325                 330                 335

Pro Ala Pro Leu Phe Thr Thr Pro Gly His Leu Leu Asp Lys Phe Ile
            340                 345                 350

Lys Glu Phe Leu Gln Pro Asn Lys Cys Phe Leu Glu Gln Ile Asp Ser
        355                 360                 365

Ala Val Asn Ile Ile Arg Thr Phe Leu Lys Glu Asn Cys Phe Arg Gln
    370                 375                 380

Ser Thr Ala Lys Ile Gln Ile Val Arg Gly Gly Ser Thr Ala Lys Gly
385                 390                 395                 400

Thr Ala Leu Lys Thr Gly Ser Asp Ala Asp Leu Val Val Phe His Asn
                405                 410                 415

Ser Leu Lys Ser Tyr Thr Ser Gln Lys Asn Glu Arg His Lys Ile Val
            420                 425                 430

Lys Glu Ile His Glu Gln Leu Lys Ala Phe Trp Arg Glu Lys Glu Glu
        435                 440                 445

Glu Leu Glu Val Ser Phe Glu Pro Pro Lys Trp Lys Ala Pro Arg Val
    450                 455                 460

Leu Ser Phe Ser Leu Lys Ser Lys Val Leu Asn Glu Ser Val Ser Phe
465                 470                 475                 480

Asp Val Leu Pro Ala Phe Asn Ala Leu Gly Gln Leu Ser Ser Gly Ser
                485                 490                 495

Thr Pro Ser Pro Glu Val Tyr Ala Gly Leu Ile Asp Leu Tyr Lys Ser
            500                 505                 510
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Ser Asp Leu Pro Gly Gly Glu Phe Ser Thr Cys Phe Thr Val Leu Gln
        515                 520                 525

Arg Asn Phe Ile Arg Ser Arg Pro Thr Lys Leu Lys Asp Leu Ile Arg
    530                 535                 540

Leu Val Lys His Trp Tyr Lys Glu Cys Glu Arg Lys Leu Lys Pro Lys
545                 550                 555                 560

Gly Ser Leu Pro Pro Lys Tyr Ala Leu Glu Leu Leu Thr Ile Tyr Ala
                565                 570                 575

Trp Glu Gln Gly Ser Gly Val Pro Asp Phe Asp Thr Ala Glu Gly Phe
            580                 585                 590

Arg Thr Val Leu Glu Leu Val Thr Gln Tyr Gln Gln Leu Gly Ile Phe
        595                 600                 605

Trp Lys Val Asn Tyr Asn Phe Glu Asp Glu Thr Val Arg Lys Phe Leu
    610                 615                 620

Leu Ser Gln Leu Gln Lys Thr Arg Pro Val Ile Leu Asp Pro Gly Glu
625                 630                 635                 640

Pro Thr Gly Asp Val Gly Gly Gly Asp Arg Trp Cys Trp His Leu Leu
                645                 650                 655

Asp Lys Glu Ala Lys Val Arg Leu Ser Ser Pro Cys Phe Lys Asp Gly
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Thr Gly Asn Pro Ile Pro Pro Trp Lys Val Pro Val Lys Val Ile
        675                 680                 685
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<301> Marie, I. and Hovanessian, A.G.
<302> The 69-kDa 2-5A synthetase is composed of two homologous and adjacent functional domains
<303> J. Biol. Chem.
<304> 267
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cgagagctca aaagatcctt ggataagaca aatgccagtc ctggtgagtt tgcagtctgc 540

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Glu Gln Phe Pro Leu Val Gln Gly Val Ala Ile Gly Gly Ser Tyr Gly
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Arg Lys Thr Val Leu Arg Gly Asn Ser Asp Gly Thr Leu Val Leu Phe
65 70 75 80

Phe Ser Asp Leu Lys Gln Phe Gln Asp Gln Lys Arg Ser Gln Arg Asp
85 90 95

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100 105 110

Trp Leu Lys Asn Asn Phe Glu Ile Gln Lys Ser Leu Asp Gly Ser Thr
115 120 125

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Ile Gln Val Phe Thr Lys Asn Gln Arg Ile Ser Phe Glu Val Leu Ala
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Ala Phe Asn Ala Leu Ser Leu Asn Asp Asn Pro Ser Pro Trp Ile Tyr
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Arg Glu Leu Lys Arg Ser Leu Asp Lys Thr Asn Ala Ser Pro Gly Glu
                165                 170                 175

Phe Ala Val Cys Phe Thr Glu Leu Gln Gln Lys Phe Phe Asp Asn Arg
            180                 185                 190

Pro Gly Lys Leu Lys Asp Leu Ile Leu Leu Ile Lys His Trp His Gln
        195                 200                 205

Gln Cys Gln Lys Lys Ile Lys Asp Leu Pro Ser Leu Ser Pro Tyr Ala
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Leu Glu Leu Leu Thr Val Tyr Ala Trp Glu Gln Gly Cys Arg Lys Asp
225                 230                 235                 240

Asn Phe Asp Ile Ala Glu Gly Val Arg Thr Val Leu Glu Leu Ile Lys
                245                 250                 255

Cys Gln Glu Lys Leu Cys Ile Tyr Trp Met Val Asn Tyr Asn Phe Glu
            260                 265                 270

Asp Glu Thr Ile Arg Asn Ile Leu Leu His Gln Leu Gln Ser Ala Arg
        275                 280                 285

Pro Val Ile Leu Asp Pro Val Asp Pro Thr Asn Asn Val Ser Gly Asp
    290                 295                 300

Lys Ile Cys Trp Gln Trp Leu Lys Lys Glu Ala Gln Thr Trp Leu Thr
305                 310                 315                 320

Ser Pro Asn Leu Asp Asn Glu Leu Pro Ala Pro Ser Trp Asn Val Leu
                325                 330                 335

Pro Ala Pro Leu Phe Thr Thr Pro Gly His Leu Leu Asp Lys Phe Ile
            340                 345                 350

Lys Glu Phe Leu Gln Pro Asn Lys Cys Phe Leu Glu Gln Ile Asp Ser
        355                 360                 365
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Ala Val Asn Ile Ile Arg Thr Phe Leu Lys Glu Asn Cys Phe Arg Gln
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Ser Thr Ala Lys Ile Gln Ile Val Arg Gly Gly Ser Thr Ala Lys Gly
385                 390                 395                 400

Thr Ala Leu Lys Thr Gly Ser Asp Ala Asp Leu Val Val Phe His Asn
                405                 410                 415

Ser Leu Lys Ser Tyr Thr Ser Gln Lys Asn Glu Arg His Lys Ile Val
            420                 425                 430

Lys Glu Ile His Glu Gln Leu Lys Ala Phe Trp Arg Glu Lys Glu Glu
        435                 440                 445

Glu Leu Glu Val Ser Phe Glu Pro Pro Lys Trp Lys Ala Pro Arg Val
    450                 455                 460

Leu Ser Phe Ser Leu Lys Ser Lys Val Leu Asn Glu Ser Val Ser Phe
465                 470                 475                 480

Asp Val Leu Pro Ala Phe Asn Ala Leu Gly Gln Leu Ser Ser Gly Ser
                485                 490                 495

Thr Pro Ser Pro Glu Val Tyr Ala Gly Leu Ile Asp Leu Tyr Lys Ser
            500                 505                 510

Ser Asp Leu Pro Gly Gly Glu Phe Ser Thr Cys Phe Thr Val Leu Gln
        515                 520                 525

Arg Asn Phe Ile Arg Ser Arg Pro Thr Lys Leu Lys Asp Leu Ile Arg
    530                 535                 540

Leu Val Lys His Trp Tyr Lys Glu Cys Glu Arg Lys Leu Lys Pro Lys
545                 550                 555                 560

Gly Ser Leu Pro Pro Lys Tyr Ala Leu Glu Leu Leu Thr Ile Tyr Ala
                565                 570                 575

Trp Glu Gln Gly Ser Gly Val Pro Asp Phe Asp Thr Ala Glu Gly Phe
            580                 585                 590

Arg Thr Val Leu Glu Leu Val Thr Gln Tyr Gln Gln Leu Gly Ile Phe
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595 600 605

Trp Lys Val Asn Tyr Asn Phe Glu Asp Glu Thr Val Arg Lys Phe Leu
610 615 620

Leu Ser Gln Leu Gln Lys Thr Arg Pro Val Ile Leu Asp Pro Gly Glu
625 630 635 640

Pro Thr Gly Asp Val Gly Gly Gly Asp Arg Trp Cys Trp His Leu Leu
645 650 655

Asp Lys Glu Ala Lys Val Arg Leu Ser Ser Pro Cys Phe Lys Asp Gly
660 665 670

Thr Gly Asn Pro Ile Pro Pro Trp Lys Val Pro Thr Met Gln Thr Pro
675 680 685

Gly Ser Cys Gly Ala Arg Ile His Pro Ile Val Asn Glu Met Phe Ser
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<301> Rebouillat, D., et al.
<302> The 100-kDa 2',5'-oligoadenylate synthetase catalyzing preferentially the synthesis of dimeric pppA2'p5'A molecules
<303> J. Biol. Chem.
<304> 274
<305> 3
<306> 1557-1565
<307> 1999
<308> NCBI/AF_063613
<309> 1999-05-04

<300>
<301> Rebouillat, D. and Hovanessian, A.G.

<302> Direct Submission
<303> Submitted (07-May-1998) Dept.of Aids and Retroviruses, Institut Pasteur
<304> 0
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Arg Arg Leu Gln Pro Arg Lys Glu Phe Val Glu Lys Ala Arg Arg Ala
            20                  25                  30

ctg ggc gcc ctg gcc gct gcc ctg agg gag cgc ggg ggc cgc ctc ggt      144
Leu Gly Ala Leu Ala Ala Ala Leu Arg Glu Arg Gly Gly Arg Leu Gly
        35                  40                  45

gct gct gcc ccg cgg gtg ctg aaa act gtc aag gga ggc tcc tcg ggc      192
Ala Ala Ala Pro Arg Val Leu Lys Thr Val Lys Gly Gly Ser Ser Gly
    50                  55                  60

cgg ggc aca gct ctc aag ggt ggc tgt gat tct gaa ctt gtc atc ttc      240
Arg Gly Thr Ala Leu Lys Gly Gly Cys Asp Ser Glu Leu Val Ile Phe
65                  70                  75                  80

ctc gac tgc ttc aag agc tat gtg gac cag agg gcc cgc cgt gca gag      288
Leu Asp Cys Phe Lys Ser Tyr Val Asp Gln Arg Ala Arg Arg Ala Glu
                85                  90                  95

atc ctc agt gag atg cgg gca tcg ctg gaa tcc tgg tgg cag aac cca      336
Ile Leu Ser Glu Met Arg Ala Ser Leu Glu Ser Trp Trp Gln Asn Pro
            100                 105                 110

gtc cct ggt ctg aga ctc acg ttt cct gag cag agc gtg cct ggg gcc      384
Val Pro Gly Leu Arg Leu Thr Phe Pro Glu Gln Ser Val Pro Gly Ala
        115                 120                 125

ctg cag ttc cgc ctg aca tcc gta gat ctt gag gac tgg atg gat gtt      432
Leu Gln Phe Arg Leu Thr Ser Val Asp Leu Glu Asp Trp Met Asp Val
    130                 135                 140

agc ctg gtg cct gcc ttc aat gtc ctg ggt cag gcc ggc tcc gcg gtc      480
Ser Leu Val Pro Ala Phe Asn Val Leu Gly Gln Ala Gly Ser Ala Val
145                 150                 155                 160

aaa ccc aag cca caa gtc tac tct acc ctc ctc aac agt ggc tgc caa      528
Lys Pro Lys Pro Gln Val Tyr Ser Thr Leu Leu Asn Ser Gly Cys Gln
                165                 170                 175

ggg ggc gag cat gcg gcc tgc ttc aca gag ctg cgg agg aac ttt gtg      576
Gly Gly Glu His Ala Ala Cys Phe Thr Glu Leu Arg Arg Asn Phe Val
            180                 185                 190
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aac att cgc cca gcc aag ttg aag aac cta atc ttg ctg gtg aag cac      624
Asn Ile Arg Pro Ala Lys Leu Lys Asn Leu Ile Leu Leu Val Lys His
        195                 200                 205

tgg tac cac cag gtg tgc cta cag ggg ttg tgg aag gag acg ctg ccc      672
Trp Tyr His Gln Val Cys Leu Gln Gly Leu Trp Lys Glu Thr Leu Pro
    210                 215                 220

ccg gtc tat gcc ctg gaa ttg ctg acc atc ttc gcc tgg gag cag ggc      720
Pro Val Tyr Ala Leu Glu Leu Leu Thr Ile Phe Ala Trp Glu Gln Gly
225                 230                 235                 240

tgt aag aag gat gct ttc agc cta ggc gaa ggc ctc cga act gtc ctg      768
Cys Lys Lys Asp Ala Phe Ser Leu Gly Glu Gly Leu Arg Thr Val Leu
                245                 250                 255

ggc ctg atc caa cag cat cag cac ctg tgt gtt ttc tgg act gtc aac      816
Gly Leu Ile Gln Gln His Gln His Leu Cys Val Phe Trp Thr Val Asn
            260                 265                 270

tat ggc ttc gag gac cct gca gtt ggg cag ttc ttg cag cgg cac gtt      864
Tyr Gly Phe Glu Asp Pro Ala Val Gly Gln Phe Leu Gln Arg His Val
        275                 280                 285

aag aga ccc agg cct gtg atc ctg gac cca gct gac ccc aca tgg gac      912
Lys Arg Pro Arg Pro Val Ile Leu Asp Pro Ala Asp Pro Thr Trp Asp
    290                 295                 300

ctg ggg aat ggg gca gcc tgg cac tgg gat ttg cat gcc cag gag gca      960
Leu Gly Asn Gly Ala Ala Trp His Trp Asp Leu His Ala Gln Glu Ala
305                 310                 315                 320

gca tcc tgc tat gac cac cca tgc ttt ctg agg ggg atg ggg gac cca     1008
Ala Ser Cys Tyr Asp His Pro Cys Phe Leu Arg Gly Met Gly Asp Pro
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gtg cag tct tgg aag ggg ccg ggc ctt cca cgt gct gga tgc tca ggt     1056
Val Gln Ser Trp Lys Gly Pro Gly Leu Pro Arg Ala Gly Cys Ser Gly
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Leu Gly His Pro Ile Gln Leu Asp Pro Asn Gln Lys Thr Pro Glu Asn
        355                 360                 365

agc aag agc ctc aat gct gtg tac cca aga gca ggg agc aaa cct ccc     1152
Ser Lys Ser Leu Asn Ala Val Tyr Pro Arg Ala Gly Ser Lys Pro Pro
    370                 375                 380

tca tgc cca gct cct ggc ccc act gcg gag cca gca tcg tac ccc tct     1200
Ser Cys Pro Ala Pro Gly Pro Thr Ala Glu Pro Ala Ser Tyr Pro Ser
385                 390                 395                 400

gtg ccg gga atg gcc ttg gac ctg tct cag atc ccc acc aag gag ctg     1248
Val Pro Gly Met Ala Leu Asp Leu Ser Gln Ile Pro Thr Lys Glu Leu
                405                 410                 415

gac cgc ttc atc cag gac cac ctg aag ccg agc ccc cag ttc cag gag     1296
Asp Arg Phe Ile Gln Asp His Leu Lys Pro Ser Pro Gln Phe Gln Glu
            420                 425                 430
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cag gtg aaa aag gcc atc gac atc atc ttg cgc tgc ctc cat gag aac     1344
Gln Val Lys Lys Ala Ile Asp Ile Ile Leu Arg Cys Leu His Glu Asn
        435                 440                 445

tgt gtt cac aag gcc tca aga gtc agt aaa ggg ggc tca ttt ggc cgg     1392
Cys Val His Lys Ala Ser Arg Val Ser Lys Gly Gly Ser Phe Gly Arg
    450                 455                 460

ggc aca gac cta agg gat ggc tgt gat gtt gaa ctc atc atc ttc ctc     1440
Gly Thr Asp Leu Arg Asp Gly Cys Asp Val Glu Leu Ile Ile Phe Leu
465                 470                 475                 480

aac tgc ttc acg gac tac aag gac cag ggg ccc cgc cgc gca gag atc     1488
Asn Cys Phe Thr Asp Tyr Lys Asp Gln Gly Pro Arg Arg Ala Glu Ile
                485                 490                 495

ctt gat gag atg cga gcg cac gta gaa tcc tgg tgg cag gac cag gtg     1536
Leu Asp Glu Met Arg Ala His Val Glu Ser Trp Trp Gln Asp Gln Val
            500                 505                 510

ccc agc ctg agc ctt cag ttt cct gag cag aat gtg cct gag gct ctg     1584
Pro Ser Leu Ser Leu Gln Phe Pro Glu Gln Asn Val Pro Glu Ala Leu
        515                 520                 525

cag ttc cag ctg gtg tcc aca gcc ctg aag agc tgg acg gat gtt agc     1632
Gln Phe Gln Leu Val Ser Thr Ala Leu Lys Ser Trp Thr Asp Val Ser
    530                 535                 540

ctg ctg cct gcc ttc gat gct gtg ggg cag ctc agt tct ggc acc aaa     1680
Leu Leu Pro Ala Phe Asp Ala Val Gly Gln Leu Ser Ser Gly Thr Lys
545                 550                 555                 560

cca aat ccc cag gtc tac tcg agg ctc ctc acc agt ggc tgc cag gag     1728
Pro Asn Pro Gln Val Tyr Ser Arg Leu Leu Thr Ser Gly Cys Gln Glu
                565                 570                 575

ggc gag cat aag gcc tgc ttc gca gag ctg cgg agg aac ttc atg aac     1776
Gly Glu His Lys Ala Cys Phe Ala Glu Leu Arg Arg Asn Phe Met Asn
            580                 585                 590

att cgc cct gtc aag ctg aag aac ctg att ctg ctg gtg aag cac tgg     1824
Ile Arg Pro Val Lys Leu Lys Asn Leu Ile Leu Leu Val Lys His Trp
        595                 600                 605

tac cgc cag gtt gcg gct cag aac aaa gga aaa gga cca gcc cct gcc     1872
Tyr Arg Gln Val Ala Ala Gln Asn Lys Gly Lys Gly Pro Ala Pro Ala
    610                 615                 620

tct ctg ccc cca gcc tat gcc ctg gag ctc ctc acc atc ttt gcc tgg     1920
Ser Leu Pro Pro Ala Tyr Ala Leu Glu Leu Leu Thr Ile Phe Ala Trp
625                 630                 635                 640

gag cag ggc tgc agg cag gat tgt ttc aac atg gcc caa ggc ttc cgg     1968
Glu Gln Gly Cys Arg Gln Asp Cys Phe Asn Met Ala Gln Gly Phe Arg
                645                 650                 655

acg gtg ctg ggg ctc gtg caa cag cat cag cag ctc tgt gtc tac tgg     2016
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acg gtc aac tat agc act gag gac cca gcc atg aga atg cac ctt ctt     2064
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        675                 680                 685

ggc cag ctt cga aaa ccc aga ccc ctg gtc ctg gac ccc gct gat ccc     2112
Gly Gln Leu Arg Lys Pro Arg Pro Leu Val Leu Asp Pro Ala Asp Pro
    690                 695                 700

acc tgg aac gtg ggc cac ggt agc tgg gag ctg ttg gcc cag gaa gca     2160
Thr Trp Asn Val Gly His Gly Ser Trp Glu Leu Leu Ala Gln Glu Ala
705                 710                 715                 720

gca gcg ctg ggg atg cag gcc tgc ttt ctg agt aga gac ggg aca tct     2208
Ala Ala Leu Gly Met Gln Ala Cys Phe Leu Ser Arg Asp Gly Thr Ser
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gtg cag ccc tgg gat gtg atg cca gcc ctc ctt tac caa acc cca gct     2256
Val Gln Pro Trp Asp Val Met Pro Ala Leu Leu Tyr Gln Thr Pro Ala
            740                 745                 750

ggg gac ctt gac aag ttc atc agt gaa ttt ctc cag ccc aac cgc cag     2304
Gly Asp Leu Asp Lys Phe Ile Ser Glu Phe Leu Gln Pro Asn Arg Gln
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ttc ctg gcc cag gtg aac aag gcc gtt gat acc atc tgt tca ttt ttg     2352
Phe Leu Ala Gln Val Asn Lys Ala Val Asp Thr Ile Cys Ser Phe Leu
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aag gaa aac tgc ttc cgg aat tct ccc atc aaa gtg atc aag gtg gtc     2400
Lys Glu Asn Cys Phe Arg Asn Ser Pro Ile Lys Val Ile Lys Val Val
785                 790                 795                 800

aag ggt ggc tct tca gcc aaa ggc aca gct ctg cga ggc cgc tca gat     2448
Lys Gly Gly Ser Ser Ala Lys Gly Thr Ala Leu Arg Gly Arg Ser Asp
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gcc gac ctc gtg gtg ttc ctc agc tgc ttc agc cag ttc act gag cag     2496
Ala Asp Leu Val Val Phe Leu Ser Cys Phe Ser Gln Phe Thr Glu Gln
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ggc aac aag cgg gcc gag atc atc tcc gag atc cga gcc cag ctg gag     2544
Gly Asn Lys Arg Ala Glu Ile Ile Ser Glu Ile Arg Ala Gln Leu Glu
        835                 840                 845

gca tgt caa cag gag cgg cag ttc gag gtc aag ttt gaa gtc tcc aaa     2592
Ala Cys Gln Gln Glu Arg Gln Phe Glu Val Lys Phe Glu Val Ser Lys
    850                 855                 860

tgg gag aat ccc cgc gtg ctg agc ttc tca ctg aca tcc cag acg atg     2640
Trp Glu Asn Pro Arg Val Leu Ser Phe Ser Leu Thr Ser Gln Thr Met
865                 870                 875                 880

ctg gac cag agt gtg gac ttt gat gtg ctg cca gcc ttt gac gcc cta     2688
Leu Asp Gln Ser Val Asp Phe Asp Val Leu Pro Ala Phe Asp Ala Leu
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ggc cag ctg gtc tct ggc tcc agg ccc agc tct caa gtc tac gtc gac     2736
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Gly Gln Leu Val Ser Gly Ser Arg Pro Ser Ser Gln Val Tyr Val Asp
            900                 905                 910

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Leu Ile His Ser Tyr Ser Asn Ala Gly Glu Tyr Ser Thr Cys Phe Thr
        915                 920                 925

gag cta caa cgg gac ttc atc atc tct cgc cct acc aag ctg aag agc     2832
Glu Leu Gln Arg Asp Phe Ile Ile Ser Arg Pro Thr Lys Leu Lys Ser
    930                 935                 940

ctg atc cgg ctg gtg aag cac tgg tac cag cag tgt acc aag atc tcc     2880
Leu Ile Arg Leu Val Lys His Trp Tyr Gln Gln Cys Thr Lys Ile Ser
945                 950                 955                 960

aag ggg aga ggc tcc cta ccc cca cag cac ggg ctg gaa ctc ctg act     2928
Lys Gly Arg Gly Ser Leu Pro Pro Gln His Gly Leu Glu Leu Leu Thr
                965                 970                 975

gtg tat gcc tgg gag cag ggc ggg aag gac tcc cag ttc aac atg gct     2976
Val Tyr Ala Trp Glu Gln Gly Gly Lys Asp Ser Gln Phe Asn Met Ala
            980                 985                 990

gag ggc ttc cgc acg gtc ctg gag  ctg gtc acc cag tac  cgc cag ctc   3024
Glu Gly Phe Arg Thr Val Leu Glu  Leu Val Thr Gln Tyr  Arg Gln Leu
        995                 1000                1005

tgt atc  tac tgg acc atc aac  tac aac gcc aag gac  aag act gtt      3069
Cys Ile  Tyr Trp Thr Ile Asn  Tyr Asn Ala Lys Asp  Lys Thr Val
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gga gac  ttc ctg aaa cag cag  ctt cag aag ccc agg  cct atc atc      3114
Gly Asp  Phe Leu Lys Gln Gln  Leu Gln Lys Pro Arg  Pro Ile Ile
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ctg gat  ccg gct gac ccg aca  ggc aac ctg ggc cac  aat gcc cgc      3159
Leu Asp  Pro Ala Asp Pro Thr  Gly Asn Leu Gly His  Asn Ala Arg
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tgg gac  ctg ctg gcc aag gaa  gct gca gcc tgc aca  tct gcc ctg      3204
Trp Asp  Leu Leu Ala Lys Glu  Ala Ala Ala Cys Thr  Ser Ala Leu
    1055                1060                1065

tgc tgc  atg gga cgg aat ggc  atc ccc atc cag cca  tgg cca gtg      3249
Cys Cys  Met Gly Arg Asn Gly  Ile Pro Ile Gln Pro  Trp Pro Val
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        35                  40                  45

Ala Ala Ala Pro Arg Val Leu Lys Thr Val Lys Gly Gly Ser Ser Gly
    50                  55                  60

Arg Gly Thr Ala Leu Lys Gly Gly Cys Asp Ser Glu Leu Val Ile Phe
65                  70                  75                  80

Leu Asp Cys Phe Lys Ser Tyr Val Asp Gln Arg Ala Arg Arg Ala Glu
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Ile Leu Ser Glu Met Arg Ala Ser Leu Glu Ser Trp Trp Gln Asn Pro
            100                 105                 110

Val Pro Gly Leu Arg Leu Thr Phe Pro Glu Gln Ser Val Pro Gly Ala
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Leu Gln Phe Arg Leu Thr Ser Val Asp Leu Glu Asp Trp Met Asp Val
    130                 135                 140

Ser Leu Val Pro Ala Phe Asn Val Leu Gly Gln Ala Gly Ser Ala Val
145                 150                 155                 160

Lys Pro Lys Pro Gln Val Tyr Ser Thr Leu Leu Asn Ser Gly Cys Gln
                165                 170                 175

Gly Gly Glu His Ala Ala Cys Phe Thr Glu Leu Arg Arg Asn Phe Val
            180                 185                 190

Asn Ile Arg Pro Ala Lys Leu Lys Asn Leu Ile Leu Leu Val Lys His
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Trp Tyr His Gln Val Cys Leu Gln Gly Leu Trp Lys Glu Thr Leu Pro
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Pro Val Tyr Ala Leu Glu Leu Leu Thr Ile Phe Ala Trp Glu Gln Gly
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Gly Leu Ile Gln Gln His Gln His Leu Cys Val Phe Trp Thr Val Asn
            260                 265                 270

Tyr Gly Phe Glu Asp Pro Ala Val Gly Gln Phe Leu Gln Arg His Val
        275                 280                 285

Lys Arg Pro Arg Pro Val Ile Leu Asp Pro Ala Asp Pro Thr Trp Asp
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Leu Gly Asn Gly Ala Ala Trp His Trp Asp Leu His Ala Gln Glu Ala
305                 310                 315                 320

Ala Ser Cys Tyr Asp His Pro Cys Phe Leu Arg Gly Met Gly Asp Pro
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Val Gln Ser Trp Lys Gly Pro Gly Leu Pro Arg Ala Gly Cys Ser Gly
            340                 345                 350

Leu Gly His Pro Ile Gln Leu Asp Pro Asn Gln Lys Thr Pro Glu Asn
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Ser Lys Ser Leu Asn Ala Val Tyr Pro Arg Ala Gly Ser Lys Pro Pro
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Ser Cys Pro Ala Pro Gly Pro Thr Ala Glu Pro Ala Ser Tyr Pro Ser
385                 390                 395                 400

Val Pro Gly Met Ala Leu Asp Leu Ser Gln Ile Pro Thr Lys Glu Leu
                405                 410                 415

Asp Arg Phe Ile Gln Asp His Leu Lys Pro Ser Pro Gln Phe Gln Glu
            420                 425                 430

Gln Val Lys Lys Ala Ile Asp Ile Ile Leu Arg Cys Leu His Glu Asn
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Cys Val His Lys Ala Ser Arg Val Ser Lys Gly Gly Ser Phe Gly Arg
    450                 455                 460

Gly Thr Asp Leu Arg Asp Gly Cys Asp Val Glu Leu Ile Ile Phe Leu
465                 470                 475                 480
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Gln Phe Gln Leu Val Ser Thr Ala Leu Lys Ser Trp Thr Asp Val Ser
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Leu Leu Pro Ala Phe Asp Ala Val Gly Gln Leu Ser Ser Gly Thr Lys
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Pro Asn Pro Gln Val Tyr Ser Arg Leu Leu Thr Ser Gly Cys Gln Glu
565 570 575

Gly Glu His Lys Ala Cys Phe Ala Glu Leu Arg Arg Asn Phe Met Asn
580 585 590

Ile Arg Pro Val Lys Leu Lys Asn Leu Ile Leu Leu Val Lys His Trp
595 600 605

Tyr Arg Gln Val Ala Ala Gln Asn Lys Gly Lys Gly Pro Ala Pro Ala
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625 630 635 640

Glu Gln Gly Cys Arg Gln Asp Cys Phe Asn Met Ala Gln Gly Phe Arg
645 650 655

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770 775 780

Lys Glu Asn Cys Phe Arg Asn Ser Pro Ile Lys Val Ile Lys Val Val
785 790 795 800

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805 810 815

Ala Asp Leu Val Val Phe Leu Ser Cys Phe Ser Gln Phe Thr Glu Gln
820 825 830

Gly Asn Lys Arg Ala Glu Ile Ile Ser Glu Ile Arg Ala Gln Leu Glu
835 840 845

Ala Cys Gln Gln Glu Arg Gln Phe Glu Val Lys Phe Glu Val Ser Lys
850 855 860

Trp Glu Asn Pro Arg Val Leu Ser Phe Ser Leu Thr Ser Gln Thr Met
865 870 875 880

Leu Asp Gln Ser Val Asp Phe Asp Val Leu Pro Ala Phe Asp Ala Leu
885 890 895

Gly Gln Leu Val Ser Gly Ser Arg Pro Ser Ser Gln Val Tyr Val Asp
900 905 910

Leu Ile His Ser Tyr Ser Asn Ala Gly Glu Tyr Ser Thr Cys Phe Thr
915 920 925

Glu Leu Gln Arg Asp Phe Ile Ile Ser Arg Pro Thr Lys Leu Lys Ser
930 935 940

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Leu Ile Arg Leu Val Lys His Trp Tyr Gln Gln Cys Thr Lys Ile Ser
945                 950                 955                 960

Lys Gly Arg Gly Ser Leu Pro Pro Gln His Gly Leu Glu Leu Leu Thr
                965                 970                 975

Val Tyr Ala Trp Glu Gln Gly Gly Lys Asp Ser Gln Phe Asn Met Ala
            980                 985                 990

Glu Gly Phe Arg Thr Val Leu Glu  Leu Val Thr Gln Tyr  Arg Gln Leu
        995                 1000                1005

Cys Ile  Tyr Trp Thr Ile Asn  Tyr Asn Ala Lys Asp  Lys Thr Val
    1010                1015                1020

Gly Asp  Phe Leu Lys Gln Gln  Leu Gln Lys Pro Arg  Pro Ile Ile
    1025                1030                1035

Leu Asp  Pro Ala Asp Pro Thr  Gly Asn Leu Gly His  Asn Ala Arg
    1040                1045                1050

Trp Asp  Leu Leu Ala Lys Glu  Ala Ala Ala Cys Thr  Ser Ala Leu
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Cys Cys  Met Gly Arg Asn Gly  Ile Pro Ile Gln Pro  Trp Pro Val
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Lys Ala  Ala Val
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<304> 179
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Ile Glu Asp Tyr Leu Leu Pro Asp Thr Thr Phe Gly Ala Asp Val Lys
            20                  25                  30

tca gcc gtc aat gtc gtg tgt gat ttc ctg aag gag aga tgc ttc caa      144
Ser Ala Val Asn Val Val Cys Asp Phe Leu Lys Glu Arg Cys Phe Gln
        35                  40                  45

ggt gct gcc cac cca gtg agg gtc tcc aag gtg gtg aag ggt ggc tcc      192
Gly Ala Ala His Pro Val Arg Val Ser Lys Val Val Lys Gly Gly Ser
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tca ggc aaa ggc acc aca ctc aag ggc agg tca gac gct gac ctg gtg      240
Ser Gly Lys Gly Thr Thr Leu Lys Gly Arg Ser Asp Ala Asp Leu Val
65                  70                  75                  80

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Val Phe Leu Asn Asn Leu Thr Ser Phe Glu Asp Gln Leu Asn Arg Arg
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gga gag ttc atc aag gaa att aag aaa cag ctg tac gag gtt cag cat      336
Gly Glu Phe Ile Lys Glu Ile Lys Lys Gln Leu Tyr Glu Val Gln His
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gag aga cgt ttt aga gtc aag ttt gag gtc cag agt tca tgg tgg ccc      384
Glu Arg Arg Phe Arg Val Lys Phe Glu Val Gln Ser Ser Trp Trp Pro
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aac gcc cgg tct ctg agc ttc aag ctg agc gcc ccc cat ctg cat cag      432
Asn Ala Arg Ser Leu Ser Phe Lys Leu Ser Ala Pro His Leu His Gln
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gag gtg gag ttt gat gtg ctg cca gcc ttt gat gtc ctg ggt cat gtt      480
Glu Val Glu Phe Asp Val Leu Pro Ala Phe Asp Val Leu Gly His Val
145                 150                 155                 160

aat act tcc agc aag cct gat ccc aga atc tat gcc atc ctc atc gag      528
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gaa tgt acc tcc ctg ggg aag gat ggc gag ttc tct acc tgc ttc acg      576
Glu Cys Thr Ser Leu Gly Lys Asp Gly Glu Phe Ser Thr Cys Phe Thr
            180                 185                 190

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gcc tgg gaa caa ggg aat gga tgt tat gag ttc aac aca gcc cag ggc      768
Ala Trp Glu Gln Gly Asn Gly Cys Tyr Glu Phe Asn Thr Ala Gln Gly
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ttc cgg acc gtc ttg gaa ctg gtc atc aat tat cag cat ctt cga atc      816
Phe Arg Thr Val Leu Glu Leu Val Ile Asn Tyr Gln His Leu Arg Ile
            260                 265                 270

tac tgg aca aag tat tat gac ttt caa cac cag gag gtc tcc aaa tac      864
Tyr Trp Thr Lys Tyr Tyr Asp Phe Gln His Gln Glu Val Ser Lys Tyr
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ctg cac aga cag ctc aga aaa gcc agg cct gtg atc ctg gac cca gct      912
Leu His Arg Gln Leu Arg Lys Ala Arg Pro Val Ile Leu Asp Pro Ala
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Asp Pro Thr Gly Asn Val Ala Gly Gly Asn Pro Glu Gly Trp Arg Arg
305                 310                 315                 320

ttg gct gaa gag gct gat gtg tgg cta tgg tac cca tgt ttt att aaa     1008
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Ser Ala Val Asn Val Val Cys Asp Phe Leu Lys Glu Arg Cys Phe Gln
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Val Phe Leu Asn Asn Leu Thr Ser Phe Glu Asp Gln Leu Asn Arg Arg
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Gly Glu Phe Ile Lys Glu Ile Lys Lys Gln Leu Tyr Glu Val Gln His
            100                 105                 110

Glu Arg Arg Phe Arg Val Lys Phe Glu Val Gln Ser Ser Trp Trp Pro
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Asn Ala Arg Ser Leu Ser Phe Lys Leu Ser Ala Pro His Leu His Gln
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Glu Val Glu Phe Asp Val Leu Pro Ala Phe Asp Val Leu Gly His Val
145                 150                 155                 160

Asn Thr Ser Ser Lys Pro Asp Pro Arg Ile Tyr Ala Ile Leu Ile Glu
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Glu Cys Thr Ser Leu Gly Lys Asp Gly Glu Phe Ser Thr Cys Phe Thr
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Glu Leu Gln Arg Asn Phe Leu Lys Gln Arg Pro Thr Lys Leu Lys Ser
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Leu Ile Arg Leu Val Lys His Trp Tyr Gln Leu Cys Lys Glu Lys Leu
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Gly Lys Pro Leu Pro Pro Gln Tyr Ala Leu Glu Leu Leu Thr Val Phe
225                 230                 235                 240

Ala Trp Glu Gln Gly Asn Gly Cys Tyr Glu Phe Asn Thr Ala Gln Gly
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Phe Arg Thr Val Leu Glu Leu Val Ile Asn Tyr Gln His Leu Arg Ile
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Tyr Trp Thr Lys Tyr Tyr Asp Phe Gln His Gln Glu Val Ser Lys Tyr
        275                 280                 285

Leu His Arg Gln Leu Arg Lys Ala Arg Pro Val Ile Leu Asp Pro Ala
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<309> 2003-04-06

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Arg Lys Ile Met Gln Ser Gln Ile Val Ser Phe Tyr Phe Lys Leu Phe
65                  70                  75                  80

Lys Asn Phe Lys Asp Asp Gln Ser Ile Gln Lys Ser Val Glu Thr Ile
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Lys Glu Asp Met Asn Val Lys Phe Phe Asn Ser Asn Lys Lys Lys Arg
            100                 105                 110

Asp Asp Phe Glu Lys Leu Thr Asn Tyr Ser Val Thr Asp Leu Asn Val
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Gln Arg Lys Ala Ile His Glu Leu Ile Gln Val Met Ala Glu Leu Ser
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<213> Homo sapiens

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<213> Homo sapiens

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<211> 737
<212> DNA
<213> Homo sapiens

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<211> 1933
<212> DNA
<213> Homo sapiens

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<212> DNA
<213> Homo sapiens

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<211> 594
<212> DNA
<213> Homo sapiens

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<210> 27
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<213> Homo sapiens

<400> 27
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<213> Homo sapiens

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<212> DNA
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<220>
<223> Synthetic DNA encoding human interferon-like peptide

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<210> 30
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<212> DNA
<213> Homo sapiens

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agcgccttgg tatgacttaa aattggaaat gtcatctaac cattaagtca tgtgtgaaca 1980

cataaggacg tgtgtaaata tgtacatttg tctttttata aaaagtaaaa ttgtt 2035

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US2005/014626

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A61K38/21 A61K9/00 A61K9/127 A61K9/51 A61P35/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A61K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, EMBASE, MEDLINE, BIOSIS, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	WO 2004/074314 A (UNIVERSITY OF SOUTH FLORIDA; MOHAPATRA, SHYAM, S) 2 September 2004 (2004-09-02) claims 1-4	23-25
Y	WO 03/092618 A (UNIVERSITY OF SOUTH FLORIDA; MOHAPATRA, SHYAM, S; BEHERA, ARUNA, K) 13 November 2003 (2003-11-13) claims 1-54	26-31

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 September 2005	12/10/2005

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Ganschow, S

Form PCT/ISA/210 (second sheet) (January 2004)

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US2005/014626

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	KUMAR M ET AL: "ROLE OF MUCOSAL IFN-GAMMA GENE TRANSFER ALLERGIC SENSITIZATION AND RSV INFECTION" JOURNAL OF ALLERGY AND CLINICAL IMMUNOLOGY, MOSBY - YEARLY BOOK, INC, US, vol. 109, no. 1, January 2002 (2002-01), page S43, XP008033852 ISSN: 0091-6749	26-31
Y	abstract	1-22
Y	LENGYEL P: "Tumor-suppressor genes: News about the interferon connection" PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA 1993 UNITED STATES, vol. 90, no. 13, 1993, pages 5893-5895, XP002347048 ISSN: 0027-8424 the whole document	1-22
A	WO 01/22970 A (THE CLEVELAND CLINIC FOUNDATION; SILVERMAN, ROBERT, H; RUSCH, LORRAINE) 5 April 2001 (2001-04-05) claims 1,2	1-22

1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2005/014626

Box II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. [X] Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

Although claims 1-22 are directed to a method of treatment of the human/animal body, the search has been carried out and based on the alleged effects of the compound/composition.

2. [ ] Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. [ ] Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. [ ] As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. [ ] As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. [ ] As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. [ ] No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

[ ] The additional search fees were accompanied by the applicant's protest.

[ ] No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US2005/014626

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2004074314 A	02-09-2004	NONE	
WO 03092618 A	13-11-2003	AU 2003225281 A1	17-11-2003
		CA 2484251 A1	13-11-2003
		EP 1579001 A2	28-09-2005
WO 0122970 A	05-04-2001	AU 1494801 A	30-04-2001
		CA 2388025 A1	05-04-2001
		EP 1229920 A1	14-08-2002
		JP 2003510281 T	18-03-2003